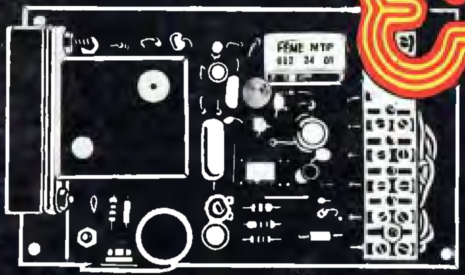
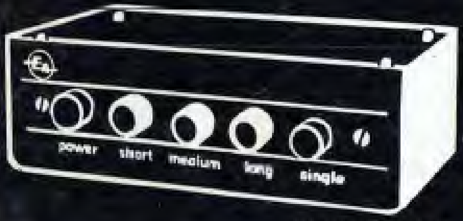
ELECTRONICS AUSTRALIA

projects & circuits

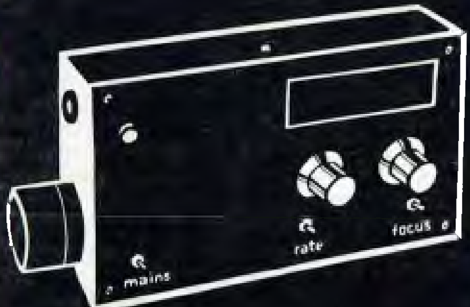
Number 2



BURGLAR ALARM



DELAY WIPER



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projects & circuits

Number 2, 1978
First printing

Produced by
Greg Swain
B.Sc. (Hons, Sydney)

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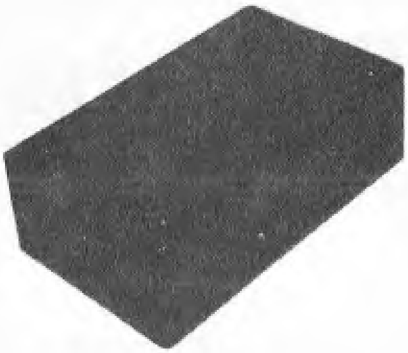
10GHz Radar Burglar Alarm



Here is the prototype burglar alarm disguised as a plastic box.

This simple microwave unit will detect moving objects at up to ten metres range. It employs the Philips CL8963 Doppler module and a circuit comprising two integrated circuits and four transistors. Everything is mounted on a small PC board and housed in an economical plastic box.

by LEO SIMPSON

The Philips CL8963 Doppler module has many applications involving the detection of moving objects. Such applications include burglar alarms, door-openers, automobile anti-collision systems, aids for the blind, batch counting systems, and speed measurement equipment. (No, we are not alluding to the Police radar.)

Contained in the CL8963 module is a Gunn diode which oscillates at 10.525 Gigahertz with a 7VDC supply. The Gunn diode is mounted in a tuned microwave cavity which has a small range of frequency adjustment via a small screw inserted about halfway along the cavity. This adjustment is set during manufacture and should not be tampered with.

In a separate microwave cavity is the mixer diode which acts as the receiver. The transmitter (Gunn diode) and receiver cavities are coupled to a common transmitting and receiving antenna, which is a small straight-sided horn. This provides a 5dB gain and a modest degree of directionality.

In normal operation, the Gunn diode transmits a beam of microwave energy. Any moving object which intercepts the beam will reflect some energy back to the antenna and thus to the mixer diode. The moving object will cause a frequency shift (Doppler effect) in the reflected wave which, when heterodyned with the local oscillator frequency, will produce an appropriate AC signal superimposed on the DC output of the mixer.

The AC signal is filtered and amplified and used to trip a relay or some other device.

Power output from the Gunn diode is a miniscule 8 milliwatts so there is no danger of injury from exposure to the microwave energy. If you were thinking of curdling the brains of unsuspecting burglars, this is not the way to go!

A circuit featuring the Philips CL8960 (now CL8963) was published in the May 1975 issue of "Electronics Australia". However this was based on preliminary information from Philips and was, apparently, not entirely trouble-free. Other circuits which have been available to hobbyists have also been less than trouble-free.

The circuit published here was developed by Electronic Developments and Service Pty Ltd. Its publication is the result of liaison between EDS, Dick Smith Electronics Pty Ltd and "Electronics Australia". EDS have considerable experience in the field of industrial electronics and have developed a number of circuits based on the Philips CL8963 Doppler module. These include simple and complex burglar alarm systems and door-openers.

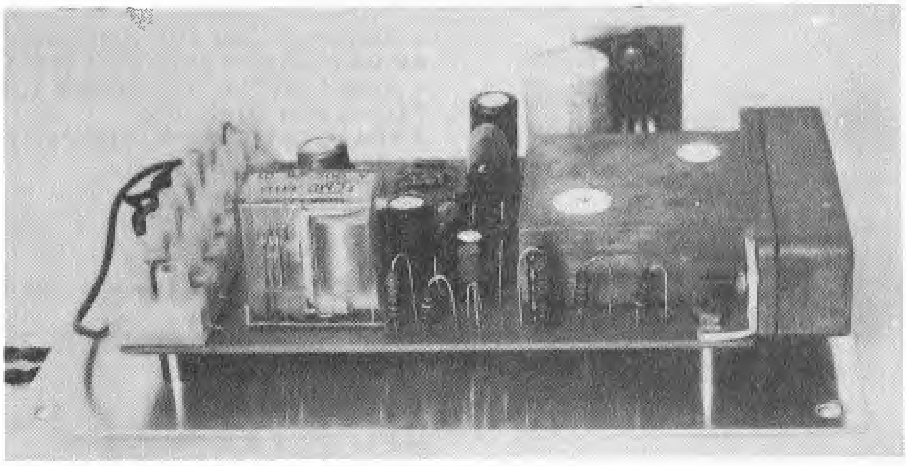
(Note: Those interested in commercial and industrial applications of Doppler modules should contact Electronic Developments and Service Pty Ltd, 27 Buckley Street, Marrickville, NSW 2204.)

As presented, the circuit uses a CL8963 to control a relay with DPDT contacts. Normally the relay is energised. If a moving body is detected, the relay opens for about 1 second. Alternatively, the relay may be made to latch in the off condition. In the latter condition, the unit may be the basis of a simple burglar alarm system. Better still, it can function as one of the sensors in a more comprehensive burglar alarm system.

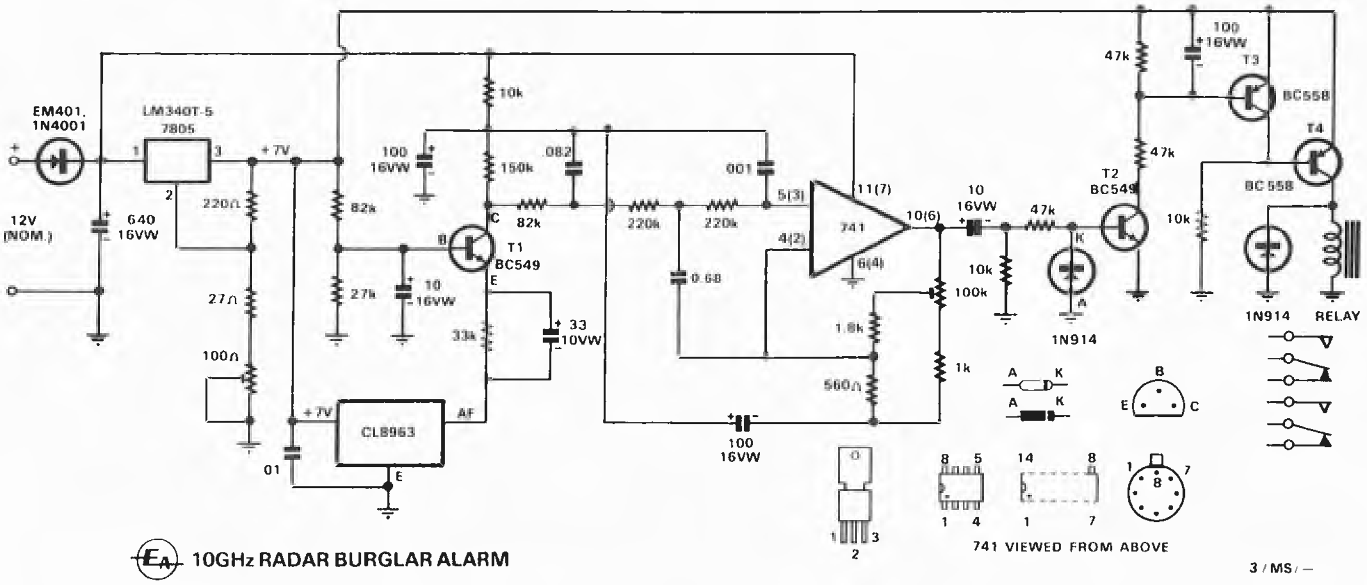
Apart from burglar alarms, another possible application for the circuit is for an automatic lighting system. Visitors to a residence could be detected as they walk up the path to enable garden and entry-way lights to illuminate automatically. This system would also have value in deterring intruders.

Compared with earlier designs, this circuit is simpler and uses more readily available parts. It is intended to be used with well-filtered DC supplies which may be anywhere from 10 to 16 volts. A 12V car battery, together with a suitable charger, would be quite suitable. Current drain is quite heavy, ranging from about 150 to 200 milliamps.

The power input diode protects the Gunn diode and other circuit components against damage from supply reversal. Combined with the 1000uF electrolytic capacitor it also provides a measure of decoupling from external circuitry. Do not regard this part of the circuit as a rectifier and filter, by the way. The circuit will not work from AC.



When the plastic box is fitted over the alarm assembly it provides a splashproof lid.



10GHz RADAR BURGLAR ALARM

Two integrated circuits, the Philips CL8963 module and a handful of other components make up this effective burglar alarm.

A 7805 regulator IC together with a voltage divider across its output provides the 7V supply for the Gunn diode. The reason for using the 7805 regulator is to provide a supply which has a very low output impedance and very low ripple output.

Since the AC output signal from the mixer diode is only of the order of a few tens of millivolts, very high gain is required to obtain a useable signal. This presents problems with signal to noise ratio both due to internally generated circuit noise and ripple on the power supply. Hence our note above on the need for a well filtered DC supply.

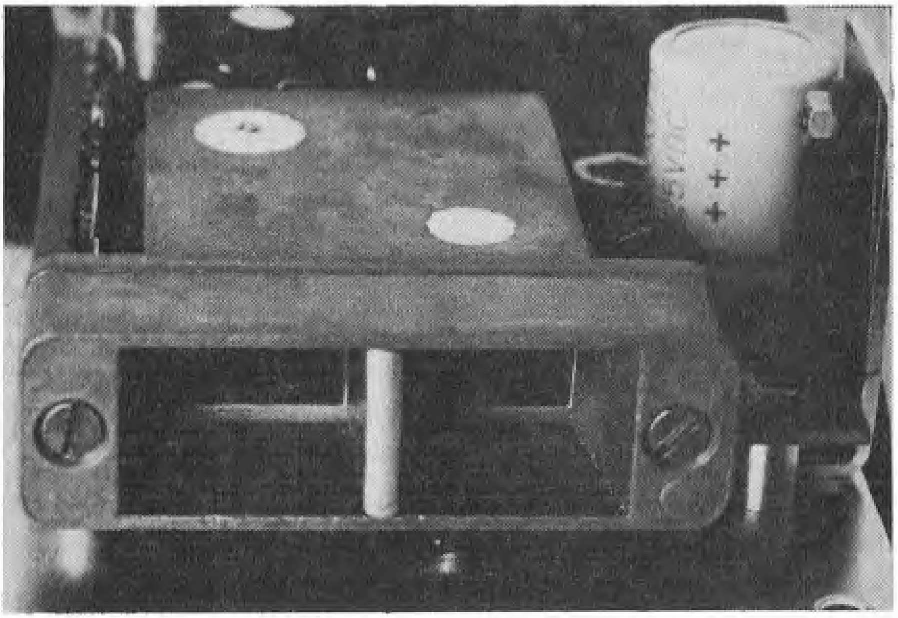
The problem of internally generated circuit noise is minimised by using a low noise transistor, T1, to drive an operational amplifier. T1 is operated at a low collector current and with low base impedance to keep input noise as low as possible.

T1 performs two functions. First it is biased via a voltage divider from the 7V supply, to provide a fixed bias current to the mixer diode to improve its sensitivity. Second, T1 acts as a common-base amplifier coupling into the 741 operational amplifier which acts as a low-pass filter with sharp cut-off above 30Hz.

A 100k preset potentiometer in the feedback circuit of the op amp acts as a gain control for the circuit and effectively modifies the range of the unit.

Output from the 741 operational amplifier is coupled via a 10uF capacitor to T2, T3 and T4 which act as the relay driver circuit. Normally, T4 conducts and holds the relay in the closed condition. When a signal of sufficient amplitude is fed from the 741, T2 and T3 conduct, causing T4 to turn off and remove power from the relay.

Normally, the relay will open momentarily when signal is detected. If the signal continues, the relay will open and shut at about once a second. We will describe how to make the relay latch in the off condition later in the article.



This photo shows how the CL8963 is modified before installing on the PCB.

One of the problems with previous designs using the CL8963 has been common impedance in the earth return. Since the Gunn diode and mixer diode have a common negative return line, high impedances (at micro-wave frequencies) can cause problems with the mixer diode and its associated circuitry.

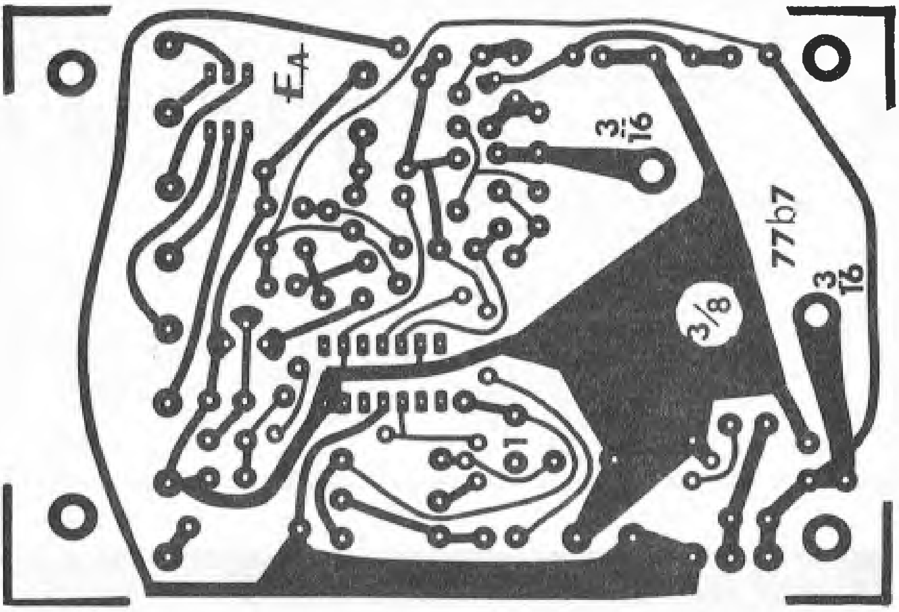
Hence we decided to mount the CL8963 module directly on the PC board. This helps minimise the problem of common impedances in the negative return line.

We also deemed it desirable to eliminate the need for a diecast box with an associated cutout for the horn antenna of the CL8963. Diecast boxes are quite expensive and most hobbyists find it difficult to cut a reasonably neat rectangular hole. The only really satisfactory method is to use a milling machine, with a special cutter so that the resultant rectangular cut-out continues the flare of the horn.

We used a small plastic box which is available quite cheaply from suppliers like Dick Smith Electronics. There is no need to drill any holes in this box, although a few holes are required in the aluminium panel which becomes the base of the unit. The result is a housing which is reasonably weatherproof (splash-proof, anyway) and it does not look like a burglar alarm.

To enable the CL8963 to be used inside the plastic box without a cutout, it must be modified. A piece of 10 SWG aluminium must be fixed into the horn assembly to divide it into two sections, as shown in our photograph. The aluminium must be cut and shaped to closely follow the flare of the horn.

10GHz RADAR BURGLAR ALARM



The PCB pattern is 117 x 79mm.

Our method was to double over a piece of 16 SWG aluminium to obtain the required thickness and then to cut and file the resultant piece to shape. The aluminium can be set in place with epoxy adhesive after the CL8963 and its horns are firmly screwed together.

All the components are mounted on the compact PC board. It is coded 77b7 and measures 117 x 79mm. The PCB should have clearance holes for the terminals and adjusting screw and lug on the CL8963 module. In addition, the terminal holes should be chamfered to allow the module to sit down flush with the PCB.

Before mounting any components on the PCB it should be used as a drilling template for the aluminium plate supplied with case (if not supplied already drilled). The PCB should be mounted exactly as shown in the wiring diagram. This shows the PCB with the regulator side positioned 3mm from the edge of the aluminium plate. This position is important otherwise either the regulator heatsink or the CL8963 module will foul the inside of the case.

Make sure that the holes in the insulated terminal block match up with the appropriate holes in the PCB. Note that the sensitivity pot should have an adjustment hole in the PCB and an appropriate clearance hole in the aluminium plate.

Having drilled the aluminium plate, assembly of the PCB can proceed. Leave the CL8963 till last, and do not remove the shorting link from the terminals. Install the horizontally mounted components and wire links first.

If a vertically-mounted 100k preset pot has been supplied instead of a horizontal type it will be necessary to extend at least the centre lead to enable correct mounting.

While we have designed the copper pattern around 14-pin ICs for the 741, the PC board is also compatible with both the 8-lead "mini-dip" and 8-lead metal can versions of the 741. This is by virtue of the fact that pins 1, 2, 7, 8, 12, 13 and 14 have no internal connection (on the 14-lead IC), while the remaining pins have the same orientation as in the smaller packages.

For both 8-lead packages, pins 1 to 4 connect to pins 3 to 6 of the socket pattern and similarly, pins 5 to 8 should connect to pins 9 to 12 of the socket pattern. The PC board layout diagram shows a mini-dip IC in position.

Low noise cracked carbon or metal film resistors of ¼W to ½W rating and 5% tolerance should be used throughout. Insert all the resistors so that their colour code bands run in the same direction. Resistors mounted "end-on" should be spaced at least 2mm off the PCB, to avoid damage during soldering.

Ensure that the electrolytic capacitors are correctly inserted, otherwise they will be reverse polarised and rendered ineffective.

The 12V relay mounts directly on the PCB. Ours was branded FEME but an equivalent type from Varley is also available.

The insulated terminal strip should be fitted as follows. Secure a 3mm length of tinned copper wire to each terminal. Bend the wires down uniformly and insert in the holes in the PCB. Locate the terminal strip temporarily with two screws through the PCB holes and solder the wires. Remove the two locating screws. Fit the small heatsink bracket temporarily to the IC regulator.

The PCB is now ready to be checked and the regulator output adjusted to 7V. Solder a resistor of between 56 and 100 ohms with 1W rating across the copper pads for the Gunn diode. Solder another

PARTS LIST

1 plastic case with aluminium lid, 158 x 50 x 96mm.
1 PCB, 77b7, 117 x 79mm
1 8-way insulated terminal strip
1 12V PCB-mounting relay with DPDT contacts (2 changeovers)
1 CL8963 Doppler module

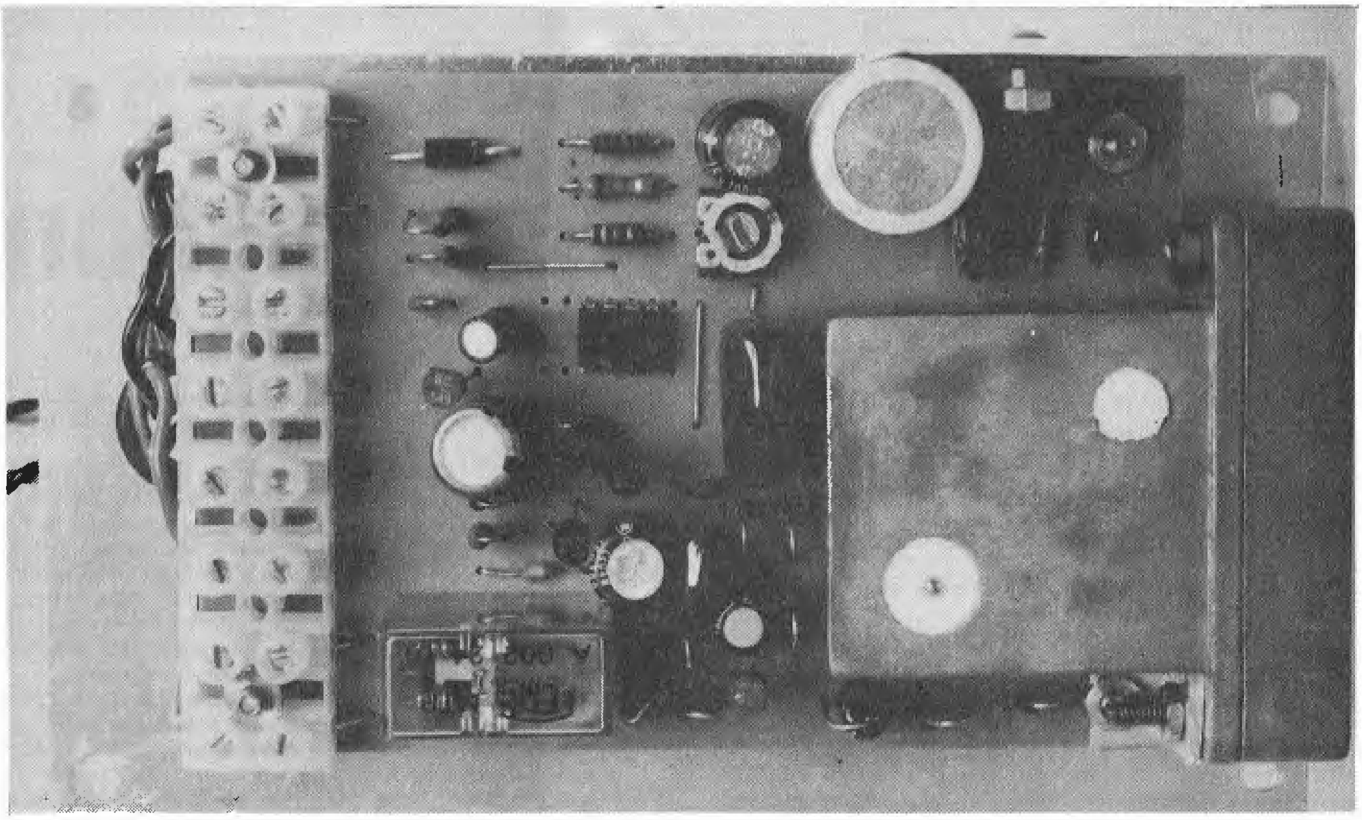
SEMICONDUCTORS
1 LM340T-5 or 7805 5V regulator
1 741 op amp integrated circuit
2 BC549 NPN low noise transistors
2 BC558 PNP silicon transistors
2 1N914, 1N4148 silicon signal diodes
1 1N4001 silicon power diode

CAPACITORS
1 640uF/16VW PC electrolytic
3 100uF/16VW PC electrolytic
1 33uF/10VW PC electrolytic
2 10uF/16VW PC electrolytic
1 0.68uF metallised polyester or polycarbonate
1 .082uF metallised polyester
1 .01uF metallised polyester
1 .001uF metallised polyester or polystyrene

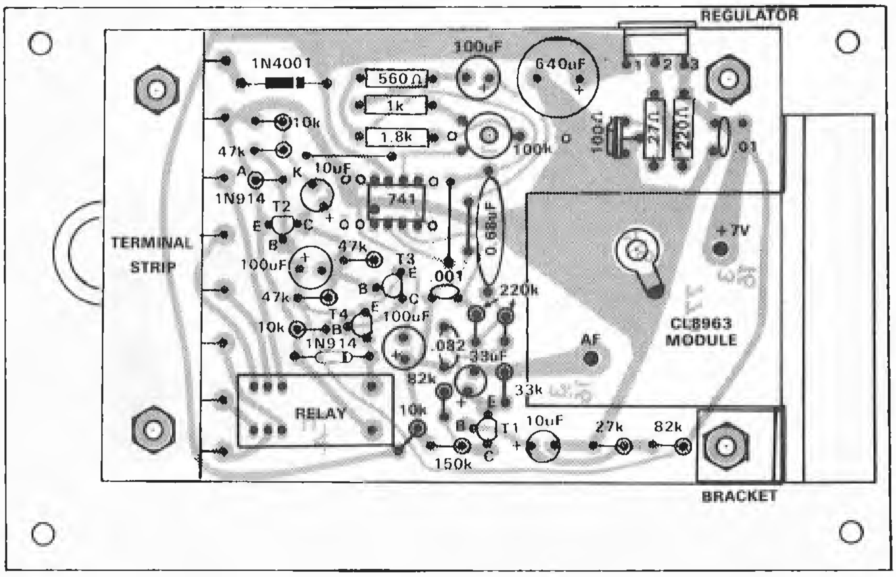
RESISTORS
(5% tolerance, ¼ or ½W unless stated)
2 x 220k, 1 x 150k, 2 x 82k, 3 x 47k 1 x 33k, 1 x 27k, 3 x 10k, 1 x 1.8k 1 x 560 ohms, 1 x 220 ohms, 1 x 56 ohms (1W for setting 7V output), 1 x 27 ohms
1 x 100k miniature preset pot (0.1" mounting centres) horizontal type preferred

MISCELLANEOUS
4 ⅜-inch spacers
1 grommet
1 bracket (to secure CL8963)
1 heatsink to suit regulator IC, hookup wire, tinned copper wire, IC regulator mounting hardware, screws, nuts, solder, epoxy adhesive.

ERRATUM: The 12V relay being supplied in kitsets for this project will not work at 6V. Fortunately, the PCB is easily modified to supply 12V to the relay. Simply cut the track running under the 10k resistor in the collector network of T1. Now join the cut section of track to the relay circuit to the 12V side of the 10k resistor.



A slightly larger than actual size photo of the alarm assembly. Note that the positioning of the PCB on the baseplate is critical.



100 ohm resistor across the copper pads for the mixer diode. These resistors temporarily substitute for the CL8963 module and allow measurements to be made.

Having checked the PCB, feed in a 12V supply and set the regulator output to 7V. This is measured across the 100 ohm resistor substituting for the Gunn diode.

If an audio oscillator is avaiable it is possible to check the operation of the filter and amplifier. Feed in across the 100 ohm resistor doubling for the mixer diode a few millivolts of low frequency signal, via a resistor at least 10k. Check that the response above 330Hz is rapidly attenuated and that the relay can be made to open for frequencies below this figure.

Now the CL8963 module can be mounted, after removing the two 100 ohm resistors.

Observe the following precautions, to avoid transient damage to the CL8963. Pretend that it is a MOS device. The soldering iron barrel should be connected to the negative supply rail on the PCB pattern with a longer jumper lead. Remove the shorting link from the CL8963 and insert in the PCB. Bend down the solder lug to firmly locate the module. Solder the lug.

Now connect and solder the other two terminals using short lengths of tinned copper wire to bridge the gap between the copper pattern and terminal. The PCB is now ready to mount on the aluminimum base plate.

Use four ⅜-inch spacers to mount the PCB. The CL8963 needs to be secured with a small metal bracket at one corner of the PCB to minimise strain. Mount the regulator heatsink so that it is hard up against the edge of the PCB. Use a mica washer and nylon insulator to isolate the regulator from its heatsink and aluminium plate.

The heatsink should be made of aluminium, say 20 SWG. The dimensions are 20 x 65mm, bent 20mm from one end. The bracket can also be made from a scrap of aluminium, 30 x 10mm and bent in the middle. When attaching the bracket to the CL8963 module make sure that the horn and its aluminium "slug" are not disturbed.

After testing the whole unit can be mounted in the case. All the leads to the unit pass through a grommetted hole in the base plate.

The unit can be set on a shelf or wall mounted using a suitable bracket. Adjust the sensitivity so that the unit is triggered by a normally sized moving body. Excessive sensitivity, particularly in small rooms, may cause false alarms.

The unit may be made to latch in the following way. Connect the supply to the unit via one set of normally open (with relay un-energised) contacts on the relay. The unit is then "armed" with the aid of a momentary contact pushbutton switch which shorts out the relay contact. Reset, after latching has occurred, is done by pressing the same pushbutton.

A control unit for intermittent wiper action

In this article we present full constructional details of a simple type of intermittent windscreen wiper control, which uses a minimum of parts, and can be fitted to almost all types of cars. Fitted with push button control, our Variable Delay Wiper will make a neat addition to your dashboard.

by DAVID EDWARDS

Almost anyone who drives a car must have found themselves in the situation where it is raining hard enough to need to use the windscreen wipers, but not hard enough to need them on continuously. As a result, one has to constantly reach for the wiper switch, turning them on and off as the need arises. This can be very tiring on a long trip, and must reduce the driver's concentration, so vital to a safe journey.

Two-speed wipers do help to alleviate this problem, but do not entirely cope with all weather situations, particularly when it is only just raining, and a wipe every few seconds or so is all that is needed. The Variable Delay Wiper control described in this article is designed to overcome this problem, in a simple, reliable and economical way.

One of the main features we have incorporated into the controller is that it should fit all makes of cars without modifications, yet at the same time be simple to build and operate. In its basic form, our controller is suitable for both positive and negative earth cars, for single and dual speed wipers, and for wound field and permanent magnet motors, including those with dynamic braking.

The second major feature we have incorporated into our design is inherent safety. When the controller is not being used, the wipers are controlled by the main wiper switch, exactly as standard. To use the Variable Delay Wiper, the main wiper switch is turned off, and the Variable Delay Wiper turned on. If during intermittent operation, it is required to use the wipers normally, operation of the main wiper switch will achieve this.

As presented in this article, the controller is only suitable for use with 12V cars. However, only one component (the relay) need be changed to enable use with 6V vehicles. This controller cannot be used in cars which are already fitted with continuously variable wipers. (These cars probably have a completely satisfactory system anyway!)

In order to make the controller applicable to all cars, we have not used a completely solid state design, but incorporated a relay as the output device. This serves four purposes: it functions as a power amplifier; it provides isolation between the electronics of the controller and the wiper circuitry; it makes possible the control of most types of wipers; and it ensures that normal operation of the wipers will be possible in the event of a failure of the controller.

The completed prototype, housed in a plastic case.

This last feature arises because the relay, in the unoperated position, does not alter the original circuitry of the main wiper control switch in any way, so that if a failure does occur, the circuitry will not be changed. If the failure is such that the relay remains energised, it is only necessary to turn off the Variable Delay Wiper to de-energise the relay.

There is of course a possibility that the relay could mechanically jam in the operated position, but the chances of this occurring should be very remote.

The conventional way of varying the delay rate of the wipers is via a potentiometer, in the same way as the volume of a radio is varied. However, we have found that this does not give satisfactory control, due to the nature of the effect being controlled.

When the volume control of a radio is varied, the change in level of the sound is detected by the ears, processed by the brain, and applied to the hands controlling the volume. This is a stable system, as any tendency for a too drastic change is immediately perceived and acted on. Of course, this requires a little practice, but this is usually easily mastered.

This system achieves stability because of the speed with which the brain can act on the information that the change is too large, and use it to control the hand. Unfortunately, there is a time delay inherent in the use of this system to control our variable delay wipers, and we can no longer achieve stable operation.

This delay arises because we are trying to control a delay. Suppose that our control is set to give a ten-second delay between wipes, and it has just finished a wipe. The next wipe is not due to commence for about ten seconds, but we decide to increase the wiping rate to one every five seconds. If we give the control pot a nudge in the correct direction, nothing happens, at least not immediately. There is no signal to tell our brain what the effect of the nudge was.

Figuratively speaking, we are floundering in the dark, so to get some sort of response, we give the pot a much larger nudge. This produces a wipe almost immediately, but we then discover that we have increased the wiping rate to one every two seconds. This was not the intended effect.

In trying to set the wipe rate back to one every five seconds, we again are floundering in the dark, and so must resort to a process of trial and error. This of course, must detract considerably from our driving concentration, leading to an increase in the risk of an accident.

This problem can be overcome by providing a calibrated scale, but this is not without disadvantages, as it is now necessary to look at the control whilst operating it. This must again necessarily reduce the driver's concentration on his immediate task.

Our solution is based on the premise that it is not necessary to have an infinite number of delays, but only say three or four, and to make these selectable by means of a switch. By making this switch simple to operate, we would introduce a minimum interruption to the driver. A further feature that we felt would be desirable to incorporate is an "instant wipe" facility, enabling the delay to be interrupted to give a single wipe.

The type of switch we chose was one of the "Isostat" push button range marketed by McMurdo Pty Ltd. These are available in a wide range of styles and configurations, and we found it possible to design a composite switch to suit our particular needs.

We have used a five switch assembly, with 20mm spacing between segments. This spacing, in conjunction with the small round knobs we have specified, means that operation of the switch should be quite simple, even for relatively large fingers.

The first section of the switch from the left is the power switch. This is a push-on push-off unit, and is fitted with a red knob.

The three middle switches are interlocked together, so that only one can be pushed in at a time. These are used to select one of three delay times available. They are all fitted with white knobs.

The fifth switch is a momentary contact one, and this is used for the single wipe function. It is fitted with a black knob.

Isostat switches are principally designed for use with a printed circuit board, any other form of connection being difficult, so use of these switches necessitated use of a small PCB.

The only other major decision to be made concerned the means of obtaining the required delay. We chose to implement this using a 555 type IC timer, as this needs a minimum of external parts, yet would give reliable operation.

Turning now to Fig. 1, we can examine the way in which we have implemented our design.

The three interlocked switches, S2, S3 and S4, are wired so that the three trimpots are normally shorted. Thus when S2 is pushed, the 10k trimpot is placed in series with the 4.7k limiting resistor, when S3 is pushed, the 47k trimpot is selected, and when S4 is pushed, the 220k trimpot is selected.

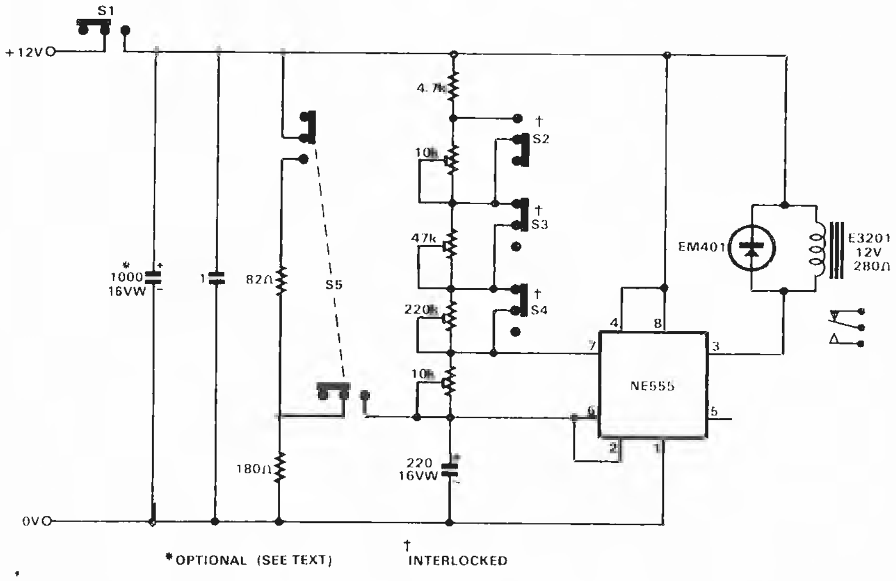


FIG. 1

VARIABLE DELAY WIPER
(FILE 3/MS/-)

Fig. 1: the circuit diagram for the Variable Delay Wiper control. The use of a relay output stage makes possible the control of most types of wipers.

The 4.7k limiting resistor is required to prevent pin 7 being shorted to the positive supply rail if the switches are manipulated so that none of them are pushed in. Similarly, if two or more are pushed in at once, the trimpots are connected in series. This arrangement was necessary to prevent damage if the switches were manipulated in a non-standard manner.

The selected trimpot, in conjunction with the second 10k trimpot, determines the charge time of the 220uF capacitor. This is the off time of the relay, corresponding to the wait between wipes. The 10k, 47k and 220k trimpots are all individually adjustable to achieve three separate delays.

The discharge time is determined solely by the second 10k trimpot, and this is adjusted to suit the particular wipers. During the discharge time, the relay is energised, and corresponds to the start of the wipe.

Although our prototype used trimpots, and we have shown them in the circuit diagram, it may be an advantage to replace them with fixed resistors, in the interests of reliability. In this case it would be best to use a trimpot to adjust the various delays, and then measure the values and fit fixed resistors of the same value.

The relay is driven directly from the output terminal of the 555 timer. Note that a protective diode is required, to prevent latch-up due to the inductive spikes produced when the relay is de-energised.

The single wipe facility is obtained by forcing the 220uF capacitor to full charge. This corresponds to a voltage of two-thirds of the supply voltage, and is achieved by means of a low impedance resistive divider formed by the 180 ohm and 82 ohm resistors. As this divider puts a considerable load on the supply rail, it is only connected when required.

LIST OF COMPONENT PARTS

1 555 timer.
1 12V 280 ohm relay, single change-over, Associated Controls type E3201 or similar.
1 EM401 diode.
1 220uF PCB mounting electrolytic capacitor.
1 1uF polyester capacitor.
1 82 ohm ½W resistor.
1 180 ohm ½W resistor.
1 4.7k ½W resistor.
1 10k preset pot.
1 47k preset pot.
1 220k preset pot.
1 printed circuit board, EA 75w3, 150 x 80mm.
1 plastic case, 127 x 65 x 41mm.
1 Isostat 5-push-button switch assembly (McMurdo reference no. 3600-5).
1 5-way terminal block.
Miscellaneous
Solder, hookup wire, brackets, machine screws and nuts, 10mm spacers.

Note: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with high ratings may generally be used, providing they are physically compatible. Components with lower ratings may also be used in some cases if available, providing ratings are not exceeded.

TABLE 1: Windscreen Motor Systems

No. of speeds	Type of Motor	No. of wires to switch	System code
1	wound field	2	1
1	wound fld, not self-parking	2	1a
2	wound field	3	2
1	permanent mag.	3	3
2	permanent mag.	4	4
cont. variable	not suitable for use with our timer		

A list of the most common types of windscreen wiper motors is given in Table 1

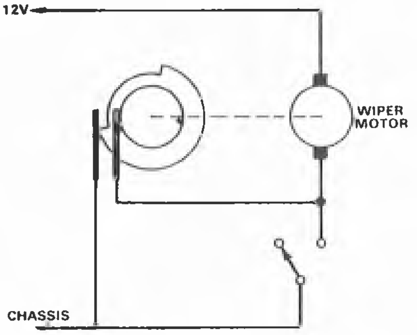


FIG. 2 SELF PARKING WOUND FIELD TYPE MOTOR SHOWN IN PARKED POSITION

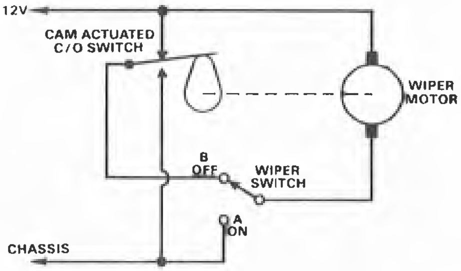


FIG 3 TYPICAL PERMANENT MAGNET MOTOR SHOWN IN PARKED POSITION

Such a low impedance divider is required to ensure that the capacitor is charged almost immediately.

It is necessary to filter the supply voltage to prevent ignition transients and surges due to load changes on the car electrics from falsely triggering the timer. This is achieved by the 1uF capacitor. In extreme cases, it may be necessary to fit a 1000uF electrolytic capacitor as well.

Before describing the construction of the unit, we will digress and give a short explanation of the various types of electric wipers commonly fitted to cars. Table 1 is a list of the more common types, and their identifying characteristics.

The earliest types of motors employed a wound field, and these were characterised by a good self-braking action. All that is required to control them is a simple on-off switch. Self parking is achieved by using a second, mechanically linked switch in parallel, which keeps power applied until the parking position is reached. Fig. 2 is a schematic diagram of such a system.

However, the more recent type of permanent magnet motor does not have the same braking characteristics, and it is necessary to apply dynamic braking by placing a short across the armature. Fig. 3 is a representative schematic circuit for these types of motors.

In the on position, the wiper motor is connected directly to the 12V supply. As the motor rotates, it operates a synchronised change-over switch. In the diagram, this switch is shown in the self-parking position, and it can be seen that there is a short directly across the motor armature.

When the wipers are turned off, the armature is earthed via the "B" contact on the wiper switch, and by the cam-actuated switch, so that the motor continues to operate. However, when the cam-actuated switch operates, it shorts out the armature, bringing the motor, and hence the wipers, to a stop. The cam is arranged so that this occurs at the bottom of the windscreen.

For all types of motors, our relay must act in a parallel fashion, so that it will turn on the wipers when the main switch is turned off, but not interfere when the main wiper is turned on. In order to do this, it is essential to use a relay with break before make contacts, such as the one specified in the parts list.

With all types of two-speed wipers, we recommend that in the intermittent mode, the slow speed is used. This will help to minimise the current through the relay contacts on switch on without seriously affecting the wiping action.

Construction of the unit should be relatively easy, as most of the components are mounted on a printed circuit board. The first stage is to mount the switch assembly on the PCB. This must be fitted with the momentary contact switch on the right hand end, as shown in the photographs. Do not push the switch right down onto the PCB, as otherwise there will not be enough clearance above the relay.

When fitting the remaining components, take care to fit them with the correct polarity. The two trimpots on the right hand end must be fitted so that their wipers do not touch, as shown in the photograph. PCB pins can be fitted to the relay outputs, as well as the power supply points.

The PCB and switch assembly is held into the plastic case by two countersunk machine screws, in conjunction with nylon spacers. We used extra nuts to lengthen the spacers, as this gave a better appearance from the front. Before fitting the PCB, drill five clearance holes for the wires to the terminal block, and fit and wire it.

The suppression components, which are not fitted onto the PCB, can be wired directly between the negative supply input and one of the tags on top of the power switch. Our photograph shows how we fitted the 1uF capacitor. If needed, the 1000uF electro. can be fitted in a similar manner, or it can be wired directly across the terminal block.

Once construction is complete, the unit can be installed in the car. A small bracket must be made, to hold the case to the underside of the dashboard. We have left the details of this to the individual constructor, as it will have to be made to suit each individual car and mounting point.

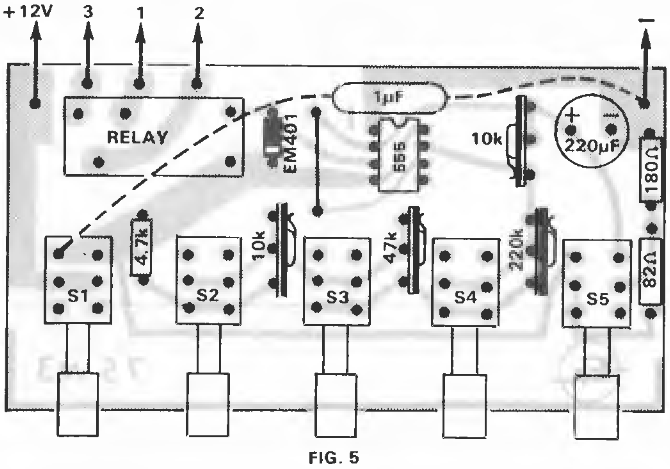
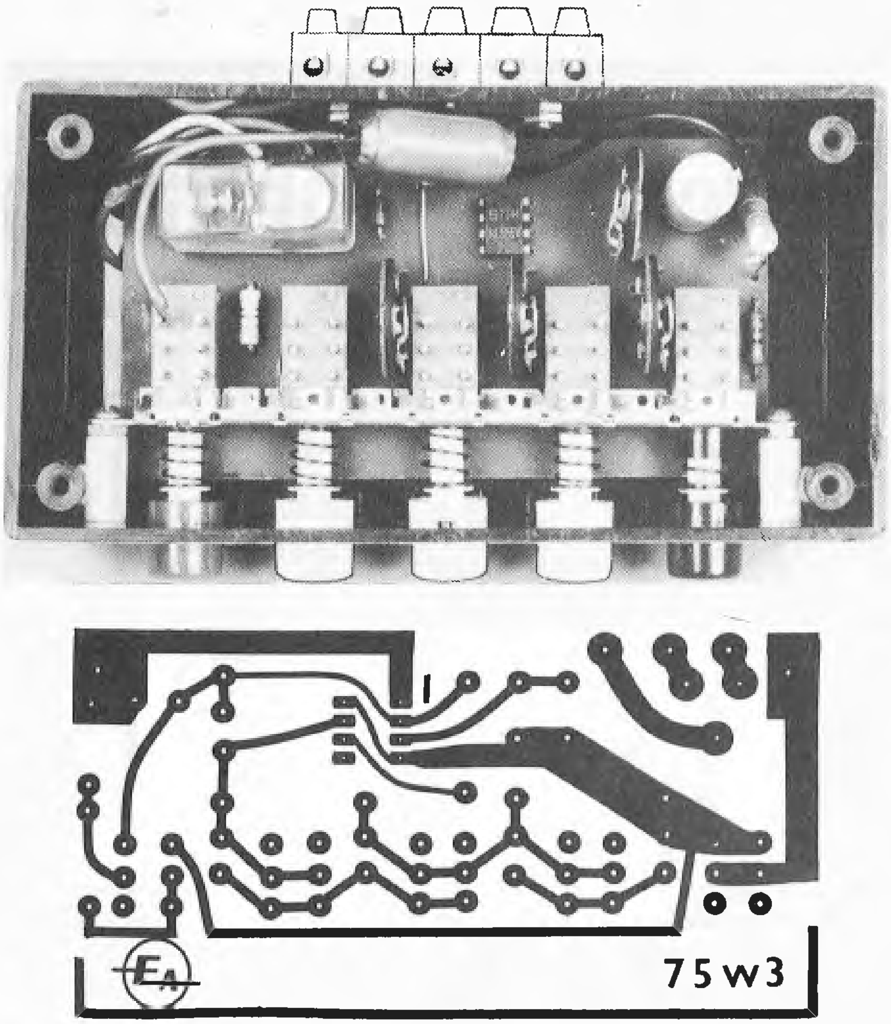


FIG. 5

Note: although not shown on the circuit and wiring diagrams, a 0.01uF capacitor should be connected between pin 5 of the 555 timer and the negative rail. This is to prevent transients from falsely triggering the timer.

Variable Delay Wiper



An interior view of the completed prototype is shown at top. Directly above is the printed circuit board pattern, shown actual size to facilitate tracing.

The next step is to complete the wiring to the electronics. First check to see if the wiring has a positive or a negative earth. If the car has a positive earth, connect the positive supply lead to some convenient earth point. It is a good idea to check with an ohmmeter that the point chosen is in fact connected to the main metalwork of the car, particularly in cars using plastic materials for the internal fittings.

If the car has a negative earth system, connect the negative supply wire to an earth point. The remaining supply wire (negative for a positive earth car, positive for a negative earth car), must be connected via the ignition switch. If your car has an accessories position, then connect this wire so that the unit will operate in this position.

Perhaps the most convenient place to connect the wire is near the fuses. Take care to connect the wire so that the unit is protected by the fuse. Connect a voltmeter between the proposed take off point and chassis, being careful to observe polarities. When the fuse is removed, the voltage should fall to zero.

It will now be possible to check the operation of the electronics. Switch on the motor, and press the timer power switch. It should be possible to hear the operation of the relay, as the various buttons are pressed. When the single button is pressed, the relay should operate for as long as the button is pressed, and for a short time after it is released.

The trimpots can now be adjusted. The 10k one nearest the 220uF electro is set to give the relay an on time of about half a second, and the remaining ones so that suitable delays are obtained.

The next step is to connect the wipers into the circuit. First ascertain what type of wipers are fitted. Table 1 is a list of the more common types. Fig. 4 gives the coding scheme we have used for the relay contacts.

We will consider system No.1 first. This type is usually fitted to early model English cars, and uses a wound field type motor with self parking facilities. There are two wires connected to the wiper switch, which is a single pole type. Connect the normally open relay contacts (2 & 3) in parallel with the wiper switch.

System No. 1a is very similar, but does not have self parking facilities. Our wiper control can be used with these wipers. Connect the normally open relay contacts (2 and 3) in parallel with the wiper switch, and adjust the on time of the relay so that the wipers give only one wipe. It will be found that this cannot be done exactly, due to the loading effects of the windscreen on the motor, but satisfactory operation can be obtained.

System No. 2 has a wound field type motor, with two speeds. There are three wires to the wiper switch. Turn the wipers on, and find and mark the wire which stops both fast and slow speeds, and the one which affects only the slow speed. Connect the normally open relay contacts (2 and 3) in parallel with the two marked ones.

System No. 3 uses a permanent magnet motor fitted with dynamic braking. There are three wires connected to the wiper switch. Identify the ground wire, i.e., the one connected to the car chassis, and mark it "A". Turn on the wipers, and find one of the two remaining wires which does not affect the operation of the wipers. The correct wire is the one which prevents the self parking facility from working. Without this wire connected, the wipers should not self park. Mark this wire "B".

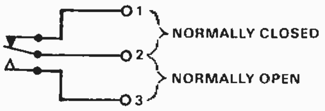


FIG. 4 RELAY CONTACTS SHOWN IN UNENERGISED POSITION

Fig. 4: the coding scheme used for the relay contacts (see text for connections).

Cut wire "B", and connect relay contacts 1 and 2 across the break, with contact 2 nearest to the switch. Contact 3 is then connected onto the earth wire A".

The last system to be considered is No. 4. This uses a permanent magnet motor with dynamic braking, but has two speeds. The procedure is very similar to that used for No. 3. Identify the earth wire, and mark it "A". Turn on the wipers in the slow speed position, and find one of the three remaining wires which does not stop the wipers, but does stop the self parking when disconnected. Mark this wire "B".

Cut wire "B", and connect relay contacts 1 and 2 across the break, with contact 2 nearest to the switch. Contact 3 is then connected onto the earth wire "A".

Having completed installation, the unit can be given a final checkout, and if necessary the trimpots readjusted. Turn on other electrical devices fitted to the car, such as the headlights and turn indicating systems, and check to see if the timer is being triggered by the resultant pulses. If so, it may be necessary to fit a 1000uF electrolytic capacitor across the supply lines.

Follow the CB action at home with our

Powermate for transceivers

This useful CB accessory will allow you to follow the CB action at home by powering your rig from the mains. The CB Powermate delivers a nominal 13.6V at 1.5 amps or more, enough to run most CB sets with an output rating of 5 watts, and includes simple short-circuit protection.

by LEO SIMPSON

While most CB activity is from cars, many operators want to carry on the conversation while at home. The easy way to do this is to remove the transceiver from the car and operate it from a suitable mains power supply.

Just about any 12V DC power source with a current rating of about 1.5 amps or more could probably be pressed into service. But few transceivers will give the best performance when operated in this way, because the power output ratings of transceivers are quoted for a DC input voltage of 13.6 or 13.8V.

There is a dual reason for this. First, it enables the manufacturer to quote higher ratings than would be possible for a 12V input. Second, which the manufacturers would no doubt hasten to point out, the normal voltage available from a car's electrical system, with the motor running, hovers just below the 14V mark.

The above remarks equally apply to radios and stereo tape players designed for use in cars. This situation has existed for at least fifteen years.

It follows then, that the way to obtain the best performance from a CB transceiver is to operate at 13.6V DC. The CB Powermate puts out 13.6V at up to 1.5 amps, which should be adequate for most models.

Powermate can also be used to power other 12V appliances such as tape players, provided their current drain is 1.5 amps or less.

Refer now to the circuit diagram. The power transformer has a centre-tapped 30V secondary winding which is coupled to a full wave rectifier and 4700uF filter capacitor to develop about 21 to 23 volts DC at no load. The output of the 4700uF is coupled to a simple series regulator consisting of a Darlington transistor pair and a 15V zener diode reference.

The Darlington pair merely acts like an emitter-follower. The reference voltage at the base of T1 determines the voltage at the emitter T2. Because each transistor has a base-emitter voltage drop of approximately 0.7V, the resulting output voltage at emitter of T2 is 15—1.4 = 13.6V.

Low hum output is a feature of the circuit. This is because any ripple voltage (hum) applied to the input of the regulator is considerably attenuated by the voltage divider consisting of the 560 ohm resistor and the dynamic impedance of the zener reference (typically about 10 ohms).

Regulation of the circuit is about 5%. Put another way, the change in voltage from no load to full load at 1.5 amps is typically 14.2V to 13.6V. Ripple ranges from less than 10mV peak-to-peak at no load to about 40mV peak-to-peak at full load.

It is possible to obtain more than 1.5 amps from the Powermate but at some point in excess of this figure, the regulation will fall off, i.e., the output voltage will fall and the hum output will increase markedly. For non-critical applications, the Powermate can supply up to 2 amps for short periods.

Transistor T3 and associated resistors comprise the overload protection circuit. T3 monitors the output current of the power supply via a 0.33 ohm resistor connected between base and emitter. When the voltage across this resistor rises above 0.6V, T3 begins to conduct and thus remove some of the bias current from the zener diode and transistors T1 and T2.

Thus for currents in excess of about two amps, T3 turns on progressively harder to limit the current to a reasonable value. The 100 ohm resistor in series with the base of T3 prevents the base-emitter junction being damaged when heavy current is flowing in the monitoring resistor.

This system of protection is effective in the short term only. If the overload is maintained for any length of time the regulating transistors, transformer and rectifier diodes would all become overheated and eventually fail. For this reason the fuse has been added to provide back up protection.

Maximum current delivered into a short circuit, before the fuse blows, will be between four and five amps.

A "foldback" protection circuit would have been another method of eliminating damage from short-circuits, but this tends to make the circuit complicated and more expensive.

Powermate is easy to build and layout is not critical, although internal wiring should be kept reasonably short and compact to avoid instability.

We built our Powermate into a compact box measuring 134 x 76 x 150mm (W x H x D) and available from Dick Smith Electronics. Rubber feet are fitted to the case.

The transformer was also supplied by Dick Smith, type DSE 6672. This is equivalent to the A&R 6672. The Ferguson PF 3559 or PL30/40VA would also be suitable. We accommodated. the few circuit components on a 12-lug length of miniature tagboard.

Three 1 ohm/1 watt resistors are connected in parallel to provide the monitoring resistor for T3. At the time of writing, these were unavailable so we had to use the more expensive alternative, an 0.33 ohm 5 watt wirewound resistor.

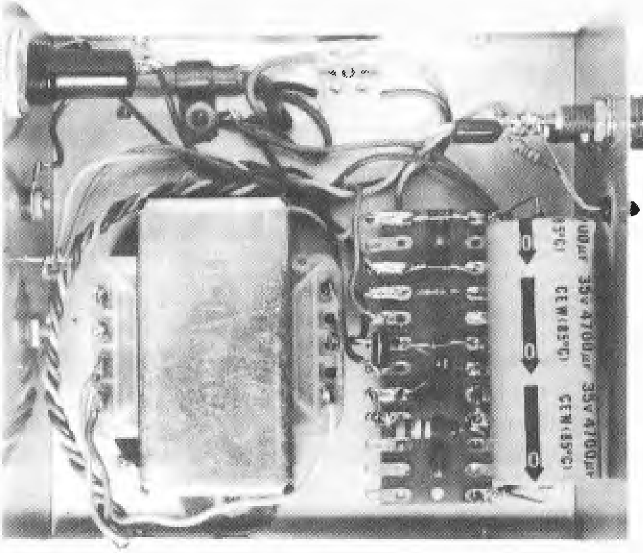
Make sure that the zener diode and transistors are correctly wired, otherwise damage is certain to result.

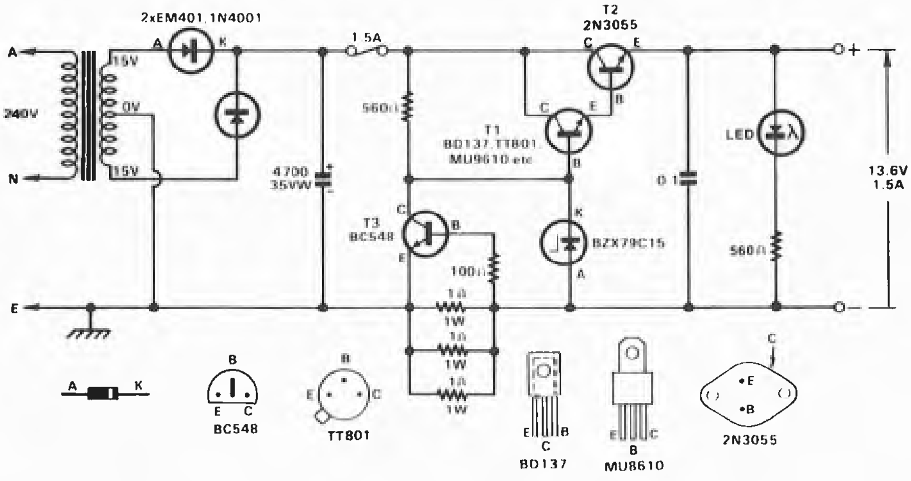
Follow this procedure for wiring the three-core mains cord: Pass the cord through a grommet in the rear of the case and anchor it with a cord clamp. The active and neutral wires are terminated in an insulated terminal block. The earth wire is soldered to a lug which is bolted or riveted to the chassis. Leave a loop of slack in the earth wire so that if the mains cord is pulled out, the earth wire will be the last to break.

PARTS LIST

metal box, 134 x 76 x 150mm
- *1 transformer with centre-tapped 30V secondary, A&R 6672, DSE 6672, Ferguson PF 3559 or PL30/40VA*
- *1 2N3055 NPN power transistor*
- *1 BD137, TT801, MU9610 NPN transistor*
- *1 BC548 NPN transistor*
- *1 BZX79/C15 or similar 15V 400mW zener diode*
- *2 EM401, 1N4001 silicon rectifier diodes*
- *1 4700uF/35VW electrolytic capacitor*
- *1 560 ohm ½W resistor*
- *1 100 ohm ¼W or ½W resistor*
- *3 1 ohm 1W resistors or 1 0.33 ohm 5W resistor*
- *1 3AG panel mounting fuseholder*
- *2 2 amp fuses (1 spare)*
- *1 12-lug tagboard*
- *1 2-way insulated terminal block*
- *2 solder lugs*
- *1 grommet*
- *2 4mm banana socket/binding posts, one black, one red*

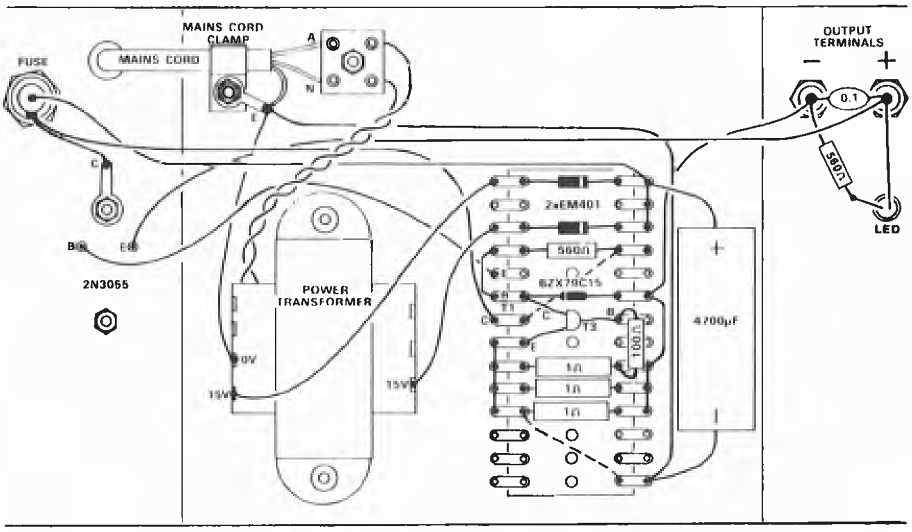
Mains cord and three-pin plug, screws, nuts, lockwashers, mica washer, insulating bushes and heatsink compound for 2N3055, hook-up wire, solder, Letraset for labelling.





CB POWERMATE (WITH PROTECTION)

Refer to both the circuit and wiring diagrams while assembling your Powermate.



The 2N3055 transistor T2 is mounted in the following way: Drill the mounting holes if not already provided. Make sure that the contact area is free of burrs and swarf. Smear the contact surface and the underside of the transistor with silicone grease or heatsink compound. A mica washer and insulating brushes must be used to isolate the transistor from the chassis. Attach a solder lug to one of the mounting screws to terminate the collector lead.

When assembly is complete, check the circuit for errors. Use the wiring and circuit diagrams for comparison with your work. Now switch on and check the voltage output. It should be close to 14V. □

Protect your loudspeakers against damage with a

Loudspeaker Protector

Ever had the misfortune to "blow" an output transistor in an amplifier without coupling capacitors? Blow your loudspeakers too? you can guard against this possibility by building the Protector circuit described here. It also eliminates switch-on "thumps" from the loudspeakers.

by LEO SIMPSON

Many hifi fans do not realise that amplifiers with direct-coupled outlets to the loudspeakers can pose a real hazard—to the loudspeakers! By direct-coupling, we are referring to those amplifiers without output-coupling capacitors. Japanese manufacturers refer to them as OCL or "output capacitor-less".

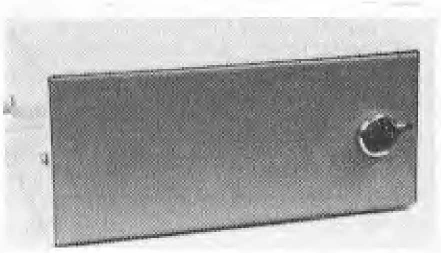
There are several advantages in having an amplifier with direct-coupling to the loudspeakers. It results in better damping factor and improved power output at low frequencies. To the designer it enables elimination of at least one large electrolytic capacitor, with a consequent cost saving. And it also eliminates one possible cause of switch-on transients.

But all these advantages add up to zero if a failure occurs in the power amplifier and applies a large DC voltage across the loudspeaker(s). The most likely result of this is that the loudspeaker voice coils are burnt out before the owner realises that anything is amiss.

While the transistor or component that fails in the amplifier may be replaced at a cost of only a few dollars, repair or replacement of the loudspeakers can be very much more expensive. In the case of many imported loudspeaker systems, replacement of a single driver may easily set you back by more than one hundred or more dollars.

Another problem which is common to many solid-state amplifiers is that of switch-on transients. This is more likely to occur in amplifiers with output coupling capacitors—when the output capacitors charge up there can be a loud thump emitted from the loudspeakers. Usually the large DC charging pulse is not likely to damage the loudspeakers, but its audible effect can be annoying.

Both of these problems can be eliminated with the Loudspeaker Protector featured here. Indeed, similar circuits are now featured in many expensive high-power amplifiers.



It may look ugly, but it can save money!

Another problem common to many solid-state amplifiers is that they can cause the loudspeakers to thump a short time after being switched off. The Loudspeaker Protector will also eliminate most of this problem, particularly where the thump occurs several seconds after switch-off.

Some amplifiers also occasionally give a sharp "crack" from the loudspeakers at the instant of switch-off. However, that is a problem which cannot be cured by this simple circuit.

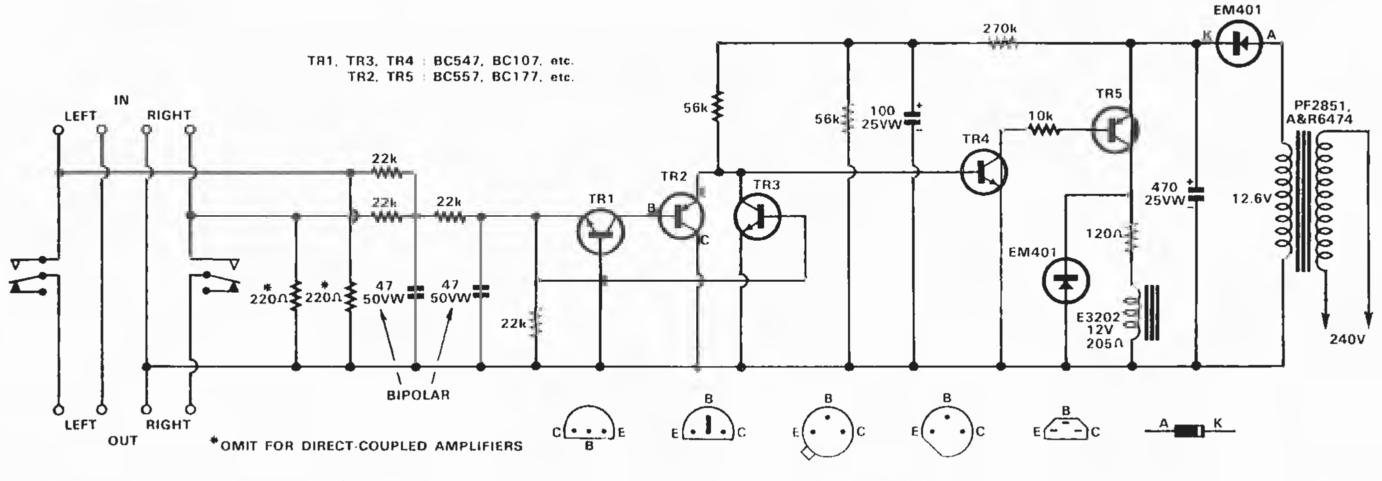
Refer now to the circuit. It is simpler than it appears at first sight. Basically it consists of a relay which normally connects the loudspeakers to the amplifier a few seconds after switch-on. If a DC voltage is subsequently applied across the loudspeakers, the relay disconnects them.

Five general purpose transistors are used in the circuit. Tr5 drives the relay direct. A diode in the collector circuit protects Tr5 against the inductive kick-back from the relay when it is de-energised. Tr4 controls Tr5 via the 10k resistor. When Tr4 conducts, so does Tr5.

Base bias for Tr4 is provided by a network consisting of two 56k resistors, one 270k resistor and the 100uF capacitor. At initial switch-on the 100uF capacitor has zero charge and so no forward bias is applied to Tr4 and the relay is off. After about two seconds, the capacitor is charged sufficiently to allow Tr4 and Tr5 to turn on and energise the relay which connects the loudspeakers to the amplifier.

Tr1, Tr2 and Tr3 form a rather

Five transistors, a relay and a few other components make up this circuit which can be built into an amplifier or as a separate unit.

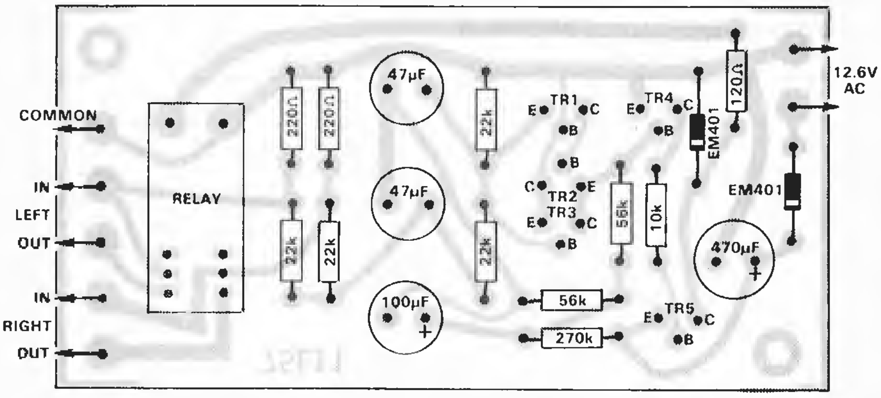


LOUDSPEAKER PROTECTOR (WITH SWITCH-ON MUTE)

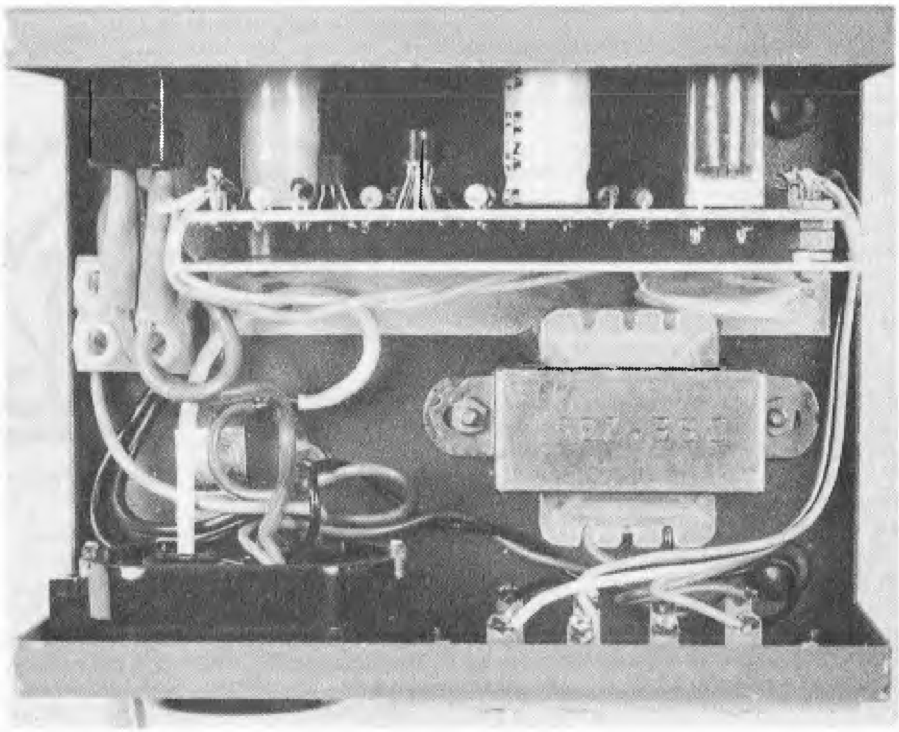
1/MS/13

incestuous triple which monitors the amplifier outputs for DC fault conditions. They function as follows:

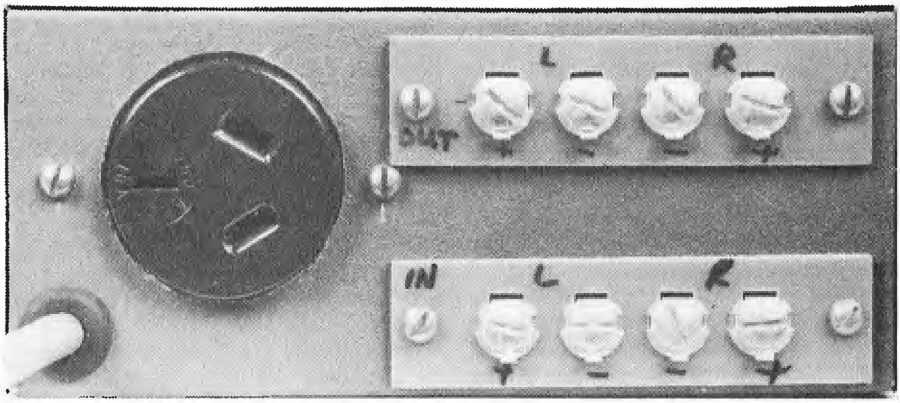
Both channels of the amplifier in question are monitored by Tr1, 2, 3 via a lowpass filter consisting of four 22k resistors and two 50uF capacitors. In a typical amplifier with direct-coupled output there is a normal "offset" DC voltage at the output which may be anywhere from about 20 millivolts to perhaps 200 to 300 millivolts. These normal offsets must not affect the monitoring network.



The PC board layout of the Protector. The 47uF capacitors are non-polarised.



The PC board was mounted vertically in the prototype. Below is the rear view.



PARTS LIST

1 case and lid

1 PC board, 102 x 51 mm, code 75L11

1 PC board bracket (see text)

1 flush-mounting mains socket

1 three-pin mains plug

1 power transformer, 12.6V secondary

1SPST toggle switch

2 four-terminal connector strips

3 BC547 NPN silicon transistors

2 BC557 PNP silicon transistors

2 EM401 silicon power diodes

1 Varley E3202 relay, 12V double-changeover contacts

1 470uF/25VW PC electrolytic capacitor

1 100uF/25VW PC electrolytic capacitor

2 50uF/50VW PC non-polarised capacitors

RESISTORS
(¼ or ½W or 10% tolerance)
1 x 270k, 2 x 56k, 4 x 22k,
1 x 10k, 2 x 220 ohms, 1 x 120 ohms.

MISCELLANEOUS
7 PC stakes, length of three core flex, solder lug, grommet, rubber feet, screws, nuts, lockwashers, hook-up wire, solder.

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with higher ratings may be used provided they are physically compatible. Lower rated components may also be used in some cases provided their ratings are not exceeded. See notes on components in the text.

If one of the amplifier outputs goes positive by more than two volts, Tr3 is forward biased and it conducts to remove the base bias from Tr4. Hence Tr4 and Tr5 turn off and the relay disconnects the loudspeakers. Similarly, if the amplifier output goes negative by more than two volts, the emitter of Tr1 is pulled negative with respect to its base. Tr1 then conducts as does Tr2, and so Tr4 and Tr5 are turned off as before.

So all the transistors function as simple switches which are only controlled by DC signals. AC signals have no effect due to the input filter.

The two 50uF capacitors in the input filter are non-polarised electrolytics. They have to be, since DC voltages of either polarity may be applied to them. The capacitors we used are made by Elna and are referred to by the manufacturer as being "bipolar"—a term normally applied to conventional transistors. We prefer the term "non-polarised".

The 220 ohm resistors on the circuit are marked with asterisks. These should be included where the Protector is used to eliminate switch-on thumps from amplifiers with output coupling capacitors. The resistors allow the output capacitors to charge in the delay period before the loudspeakers are connected. If the resistors were omitted there would be an awful bang from the loudspeakers when the relay is energised.

While the 220 ohm resistors are essential where the Protector is to be used with amplifiers having output capacitors, they should be omitted where used with amplifiers having direct-coupled outputs. If they are included there is a strong likelihood that they will be burnt out in the event of an amplifier fault.

As it stands, the Protector circuit can be built in a number of forms. First, it can be built into the amplifier it is to work with, and powered from it. The supply rail may be anywhere in the range from 12 to 45V DC. The only change necessary to adapt to differing supply rails is that the 120 ohm resistor should be varied so that no more than 12V is applied to the relay. Coil resistance of the relay specified is 205 ohms.

Current drain of the circuit with the relay energised is close to 60 milliamps. If it is run from the main positive DC rail in the amplifier the diode and 470uF filter capacitor may be omitted. Note that the zero volt rail (ie, earth) of the Protector should connect to the main earth point of the amplifier.

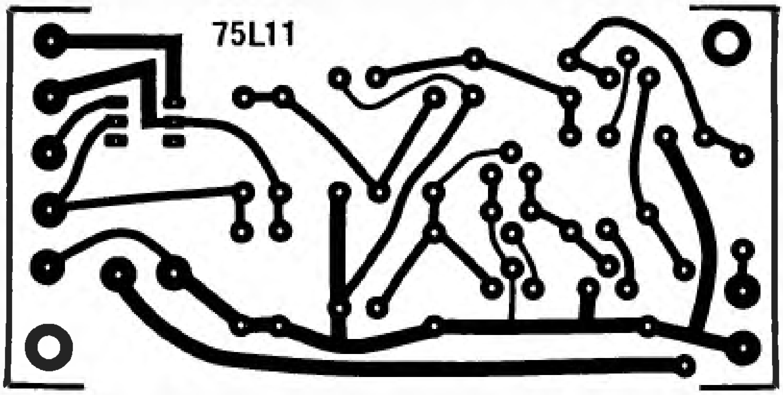
If it is inconvenient to power the Protector from the main positive DC rail of the amplifier it is possible to run it from an AC winding on the power transformer provided that one side of the winding is, or can be connected to the main earth of the amplifier. AC input voltage to the rectifier of the Protector may be in the range of 9 to 30VAC. If the resultant DC voltage is more than 25V, the voltage rating of the 470uF filter capacitor should be increased accordingly.

Where the constructor does not wish to incorporate the Protector into an existing amplifier it will be necessary to construct it as a separate unit with its own small transformer to provide the DC supply. Here again it can be built in one of two versions. Note that the Protector transformer must be energised at the same time as the amplifier.

Where the amplifier in question has switched 240VAC outlets the Protector can be plugged into the rear of the amplifier and controlled by the amplifier power switch. If the amplifier does not have a switched 240VAC outlet, the Protector will be required to have its own power switch and a 3-pin mains socket into which the amplifier can be plugged. The amplifier is then turned on and off with the Protector power switch. Our prototype is the latter version.

Our prototype was housed in a neat little case supplied by Bespoke Metalwork, 42c Sydenham Road, Brookvale, NSW. The case is denoted type MT1, comes in crackle enamel finish of blue, black or red and has a clear anodised aluminium lid. Dimensions are 136 x 60 x 104mm (W x H x D). Parts suppliers can order from Bespoke at the above address.

A flush mounting 3-pin outlet and two sets of four-way screw terminals are mounted on the rear of the case. The sets of terminals are for connection of output wires from the amplifier and wires to the loudspeakers. The front panel is bare except for the power switch.



Here is the full size copper pattern of the PC board.

A PC board coded 75L11 and measuring 102 x 51mm accommodates the circuitry. The relay is made by Varley, type E3202, and is soldered directly to the PC board. The non-polarised electrolytic capacitors can be soldered in either way round.

General-purpose small-signal silicon transistors can be used for this circuit. Tr1, 3 and 4 may be BC548, BC108 or any equivalent NPN type, but if the circuit is incorporated into an amplifier and has a DC rail of more than 30V then Tr4 should be BC547, 107 or equivalent. Similarly, Tr2 and Tr5 may be BC558, BC178 or equivalent PNP type, but if the supply rail is more than 30V, Tr5 should be BC557, 177 or equivalent.

Note that if the resistor in series with the relay is modified to cope with a higher voltage DC rail, its power rating should be adequate for the purpose. For a DC rail below 20V, a ½W resistor will suffice.

As it stands, the Protector is suitable for amplifiers with ratings up to about 100 watts RMS per channel. If it is to be used with higher rated amplifiers a relay with higher rated contacts will have to be used. The contacts in the relay specified have a rating of 5 amps.

Use PC stakes or pins to make connections to the PC board. These make it easy to make and break connections. The PC board was mounted on a vertical bracket slightly larger than the board and made of aluminium.

The power transformer is a miniature type with a 12.6V secondary. Ferguson PF 2851, A & R 6476 or DSE 2851 are suitable.

These transformers normally have a centre tap connection to the secondary. This should be coiled up and taped to prevent it shorting to the case.

The three-core mains cord should be passed through a grommeted hole in the rear of the case and anchored with a cord clamp. The earth conductor should be terminated to a solder lug on the chassis while the active and neutral wires are terminated to an insulated terminal block. Connections to the power switch, transformer and AC outlet are then made from the terminal block. On no account should any connection be made from the Protector chassis to the earth returns of the loudspeakers or amplifier

When assembly is complete, the Protector can be checked for correct operation without connecting it to an amplifier. Switch on and check that the relay closes after about two seconds. Drop out time for the relay after switch-off is about half a second. A shorter delay before the relay closes will occur if the Protector is switched on immediately after it is switched off.

Fault conditions at the input can be simulated with a nine-volt battery. Just connect across the inputs, either way, and the relay should open after a short delay of less than half a second. If you connect the battery to the output terminals of the Protector you can check that the relay is correctly breaking the circuit when a fault occurs. If it is, the relay will open and close repeatedly until the battery is removed.

When operation of the circuit has been checked, the unit can be connected to the amplifier and loudspeakers.

You can then sigh with relief, because your precious loudspeakers are now safe from damage if your amplifier pops an output transistor.

There is one other advantage of the Protector. It enables you to quickly kill the sound of an objectionable program, rather than letting it fade away after normal switch-off. For example, blah blah razzle dazzle and (click) . . .

Use an SCR or Triac in this

Speed Control for Electric Drills

These two simple SCR circuits allow electric drills to be used over a wide range of speeds while still maintaining good torque. They are also suited for other appliances using "universal" brush-type motors such as circular saws, jig-saws, food-mixers and movie projectors.

by LEO SIMPSON

An electric hand drill is nowadays regarded as an essential tool in any handyman's kit, and is called upon to perform a multiplicity of tasks. Apart from the mundane jobs of drilling holes and powering various attachments such as circular saws and orbital sanders, it is also used to drive pumps, stir paint, and polish furniture or the family car.

As versatile as the electric drill may be, however, the chuck speed is often too high, even on the two-speed models. This is a problem when larger drills and bits are used, particularly in the case of masonry drills.

Both of the speed controls featured here enable a large range of useful speeds to be obtained, as much as ten-to-one in some cases. This means that larger drill bits can be used for drilling in metal with ease. And with the control adjusted to give the lowest usable speed, your electric drill makes a very efficient screwdriver which can be a real boon when there are a large number of screws to be driven (for example, when assembling a loudspeaker cabinet).

An important point to remember when using this type of speed control is that it should only be used for intermittent operation. This is not because of any limitation on power dissipation within the controller, but due to temperature rise within the drill motor. When the motor runs at low speed its inbuilt fan is ineffective, so that there is little airflow to cool the armature. So make it a practice to only use the controller for a few minutes at a time.

Another point to consider is that if the drill is used very frequently with the controller there is a possibility of shorter brush life and also reduced commutator life. This is because of the higher peak currents which result from low speed operation with the SCR control.

If you anticipate that your drill will be required to perform a large amount of low-speed work then it may be better to consider a separate low speed drill such as one of the rechargeable cordless units now available at an attractive price.

Even when the above limitations are taken into account, the SCR speed control can greatly extend the usefulness of your single-speed or two-speed electric drill. And the total cost of the circuit components is only about five dollars.

Now let us describe the operation of both circuits. The first, designated "Drill Speed Control Mk 1", was originally published in "Electronics Australia" in May 1971. We have modified it slightly, but the basic circuit essentially remains the same.

Heart of the circuit is the SCR or silicon controlled rectifier(also known as thyristor), which behaves like a special sort of rectifier diode which only conducts in the forward direction when it is triggered by a small positive voltage applied between gate and cathode. Once triggered into conduction, the SCR will continue to conduct until the current falls to zero or the anode-to-cathode voltage reverses.

Thus an SCR can be used to control the amount of AC power fed to a load by varying the instant during each positive half-cycle at which it is triggered into conduction. If the SCR is triggered early in each positive half-cycle more power will be delivered to the load than if it is triggered late in each positive half-cycle. This method of control is referred to as "phase control" since the SCR trigger point is varied with respect to the phase of the AC supply voltage.

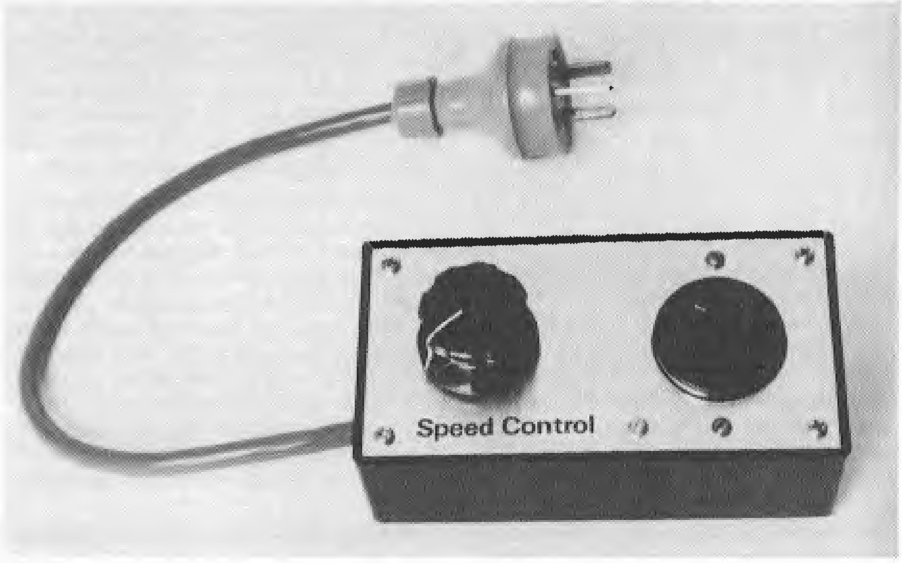
In this circuit the SCR trigger point is controlled to a large extent by the "back EMF" generated by the motor. The "back EMF" can be defined as a voltage developed by a motor which opposes the supply voltage. The back EMF of any motor is directly proportional to its speed.

Refer now to the circuit of the Mk I version. The SCR is connected in series with the output socket so that then it is non-conducting, no power is applied to the motor. A divider chain consisting of an 11k resistor (actually 3 x 33k/1W resistors in parallel) a 1.8k resistor and a 2k potentiometer provide a positive-going reference voltage for the SCR gate, via diode D2. Diode D1 reduces the power dissipation of the series resistor chain by half and protects the SCR gate if the load is open circuit, as for example, when the motor is switched off.

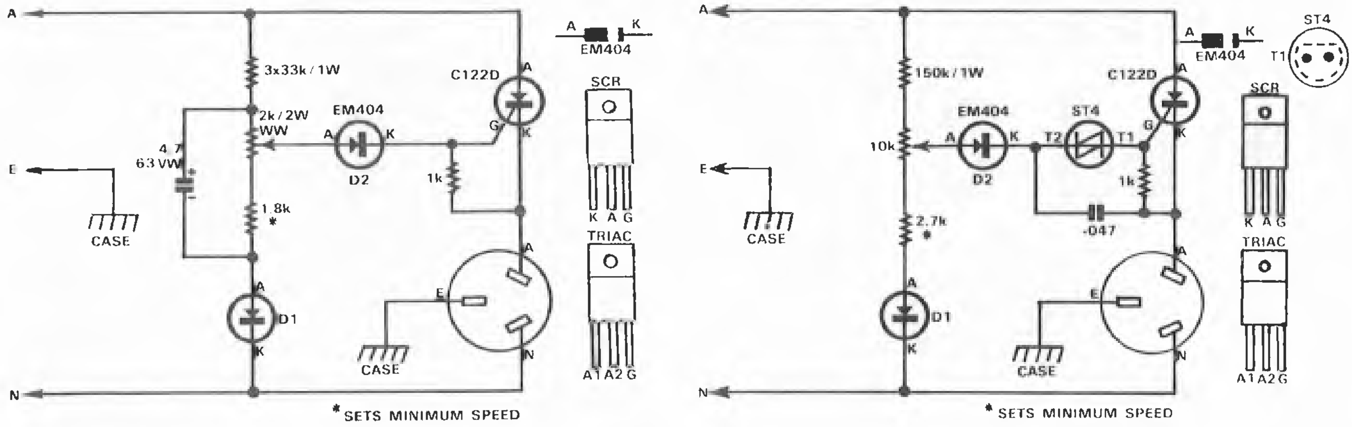
Diode D2 protects the gate of the SCR when it is in the conducting state.

The triggering voltage for the SCR is controlled by the setting of the 2k potentiometer. During each positive half cycle of the AC supply when diode D1 conducts, the pot provides a sinusoidal triggering voltage with amplitude variable from 20V to 50V RMS approximately. Ignore the capacitor connected across the potentiometer for the moment.

The voltage applied by the potentiometer wiper is not the effective SCR triggering voltage because the motor is



An economical plastic box makes an attractive case for the Drill Speed Control.

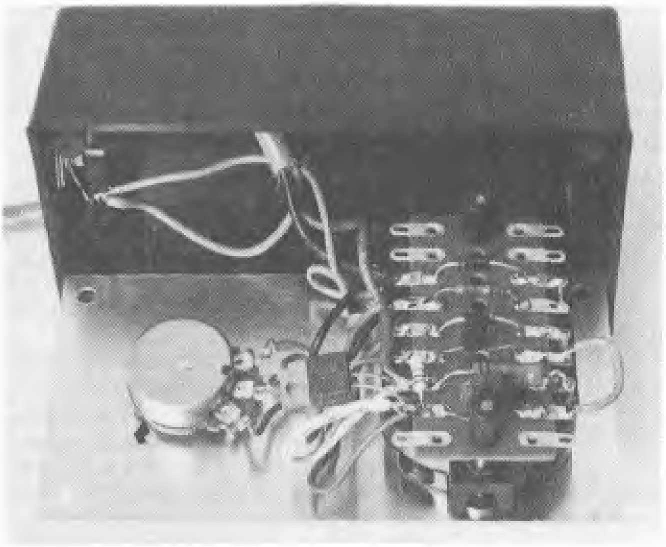


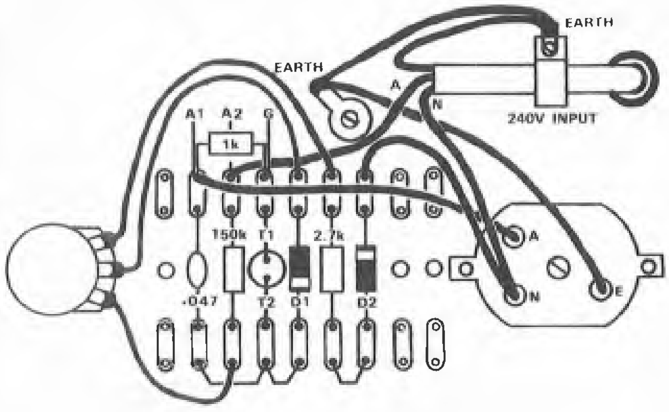
DRILL SPEED CONTROL MK1

DRILL SPEED CONTROL MK2

2/PC/22

Both of these circuits give good speed control characteristics with electric drills. They are for intermittent use only.





Use the wiring diagram and the photograph opposite to assemble your Speed Control. All exposed metalwork of the case must be earthed, as in the diagram.

connected in series with the SCR cathode. This means that the effective SCR trigger voltage is that applied by the pot wiper minus the motor back-EMF. Thus we have negative feedback from the motor, which will act to maintain motor speed despite load variations.

Note that there are actually TWO different back-EMFs from the motor: one present during the conduction periods of the SCR and the other present during the negative half-cycles and the early part of the positive half-cycles before the SCR is triggered into conduction. It is this latter back-EMF which controls the firing point of the SCR as described above.

As the motor back-EMF rises with increasing speed, the effective SCR triggering voltage is reduced so that it is triggered later in each half-cycle and supplies less power to the motor. The motor speed ceases to rise when the SCR trigger voltage is reduced to a level where the SCR is only just supplying sufficient power to maintain the selected speed.

If the load on the motor increases, it will tend to slow down and the back-EMF will be reduced in proportion. This increases the effective SCR trigger voltage so that it conducts earlier in each positive half-cycle. Thus more power is delivered to the motor to maintain the selected speed.

The circuit as described so far is quite satisfactory if the SCR trigger angle is 90 degrees or less. This corresponds to relatively fast motor speeds. However, if lower motor speeds are required, corresponding to an SCR trigger point later in each half-cycle than 90 degrees, the above feedback system will not work.

If the SCR is already firing at 90 degrees and the motor speed rises slightly due to a reduction in load, the gate trigger voltage necessary for the SCR to be triggered later will not be available, since at 90 degrees the gate voltage is at maximum. As a result, the SCR may not conduct for the next one or two positive half-cycles until the motor speed drops below the selected speed. Thus the motor will tend to "hunt" or "cog" as it attempts to adjust to a stable operating mode.

A major improvement in this respect is obtained by connecting the 4.7uF capacitor across the potentiometer and 1.8k resistor. This converts the sinusoidal gate voltage waveform from the potentiometer to a "ramp" waveform which reaches a peak near the end of each positive half-cycle. The result is reliable triggering over a greater part of the half-cycle and considerably smoother running at low motor speeds. Note that there will still tend to be some "cogging" at low speeds. The 4.7uF capacitor is not a complete cure.

The 1.8k resistor in series with the potentiometer sets the minimum speed of the motor and ideally it should be selected to suit the motor the control will normally be used with. If the resistor is too large, the minimum motor speed will be too high and if the resistor is too low there will be a "dead spot" at low settings of the potentiometer.

The 1k resistor between gate and cathode of SCR is often omitted from similar speed control circuits but it is recommended by the SCR manufacturers. It reduces the possibility of false triggering due to leakage and dv/dt effects and consequently lessens the chance of catastrophic failure in the device. So while this circuit has three extra components compared to the most rudimentary circuits we have seen, the overall improvement in operation is well worth the small extra cost.

While the Mk I version of the speed control is entirely adequate, it does have several drawbacks. The first is that it has a power dissipation in the series resistor string of about 3 watts. The second is that the current through the resistor string may not be adequate to give reliable triggering with the more insensitive SCRs. The only cure for this in the Mk I circuit is to increase the current in the resistor string, which will further increase the power dissipation. The third drawback is that the potentiometer needs to be a wirewound unit with a rating of 2 watts or more.

These wirewound potentiometers are now quite expensive, at around $2.50, and may be at times difficult to obtain. (We understand that at the time of writing, Radio Despatch Service, 869 George Street, Sydney, have a large stock of these pots selling below the current wholesale price.)

So while the Mk I version of the speed control has the inherent advantage of simplicity we have developed the Mk II version to overcome the above drawbacks. As can be seen from the circuit, it is very similar in configuration, the main change being the addition of an ST4 trigger device and a .047uF capacitor between the SCR cathode and the junction of the diode D2 and the ST4.

The ST4 is a breakover device similar to a diac except that while a diac has breakover voltage of about 30 volts in either direction, the ST4 is asymmetrical. In one direction it has a breakover voltage of about 16 volts from which it breaks down with a relatively high impedance with a conduction voltage of about 8 volts; in the other direction it has a breakover voltage of about 8 volts and a low conduction voltage of about 1½ volts. We use it in this circuit in the latter mode only so that it is equivalent to a Silicon Unilateral Switch (SUS).

Instead of using the voltage from the pot wiper to trigger the SCR directly as in the MK 1 circuit, the pot wiper voltage is used to charge the .047uF capacitor via diode D2. When the capacitor is charged to the ST14 breakover voltage a high energy pulse is delivered to the gate of the SCR, triggering it into conduction.

In this circuit, the motor back-EMF acts to reduce the charging voltage to the .047uF capacitor rather than reducing the effective SCR gate voltage as before. The net effect is still the same and the feedback is just as effective. However, the circuit is much more efficient since there is less power dissipation—only about 200 milliwatts, in fact. Note that we have specified a 150k resistor with a rating of 1W to ensure it has adequate voltage rating.

The 2.7k resistor in series with the 10k potentiometer again sets the minimum motor speed. The 10k pot is a standard ½ watt carbon element type with a linear resistance characteristic.

Comparisons with a variety of electric drills indicate that perhaps the Mk I circuit is a trifle smoother in low speed operation, while the Mk II circuit has marginally better torque characteristics (at low speed).

Both the circuits described here are featured with the General Electric plastic-pack SCR, C122D. This has a DC rating of 8 amps and a blocking voltage rating of 400 volts. Using this SCR, both circuits are suitable for electric drills or appliances with "universal" brush-type motors having nameplate ratings up to 3 amps. With motors of this rating or less, the SCR specified will be able to withstand the "locked rotor" current if the motor is stalled.

We do not recommend the substitution of higher rated SCRs to enable bigger motors to be used. If a higher power control is required the circuit should be redesigned to suit the different characteristics which can be expected from higher power motors.

On no account should a speed control circuit such as this be used with induction motors.

Construction details of either circuit are quite simple. We mounted the prototype in a plastic box measuring 130 x 68 x 42mm (available from Dick Smith Electronics). The thin aluminium panel supplied with the box is not strong enough to prevent buckling once the cut-out for the flush-mounted mains socket is made. It should be suitably braced or discarded in favour of a plate made of 22 gauge or thicker steel.

Long mounting screws are used to secure the AC socket and these also mount the nine-way tagboard. Use nuts or washers to space the tagboard a suitable distance above the AC socket.

The C122D SCR may be soldered directly into circuit and does not require a heatsink. If this SCR is hard to come by, a 400V Triac such as an SC141D may be substituted. It is soldered in the same way. (A2 is equivalent to the anode of an SCR while A1 is equivalent to the cathode.) The ST4 asymmetrical trigger device should be soldered in as shown in the wiring diagram. Incorrect polarisation will not result in damage but will cause ineffective speed control.

The earthing details must be followed exactly. All exposed metalwork is to be earthed. This includes the mounting screw for the mains cord cable clamp. A grommet should be fitted to the entry hole in plastic case to prevent chafing of the mains cord.

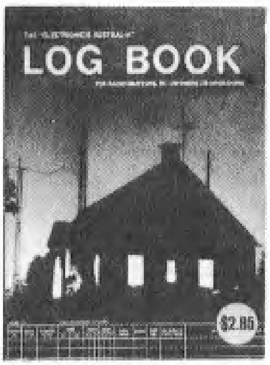
Failure to follow these wiring details could result in a lethal appliance. Observe them carefully.

SPEED CONTROL PARTS LIST

(Mk. II version)

1 plastic box, 130 x 68 x 42mm with steel front panel.
1 Clipsal flush-mount AC socket
1 nine-way miniature tagboard
1 knob
1 C122D silicon controlled rectifier
1 ST4 asymmetrical trigger device
2 EM404 400V silicon diodes
1 0.047uF/100VW polyester (greencap) capacitor
1 10k(lin) potentiometer
1 x 150k/1W, 1 x 2.7k/¼W resistor
2 solder lugs
1 cable clamp
1 grommet
Mains cord, plug, connecting wire, screw, nuts, lockwashers, solder.

Note: Components with higher ratings may be used if physically compatible. Do not use components with lower ratings.



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An Upgraded Capacitor Discharge Ignition System

by LEO SIMPSON

With car maintenance and running costs rising all the time, there is an increasing demand for a reliable solid-state ignition system which is simple and easy to build. Here we present an upgraded version of the Capacitor Discharge Ignition system featured in August, 1970.

In the years since August, 1970, we have had some doubts about capacitor discharge ignition systems; in particular, about their reliability. These matters were discussed in the June 1973 issue, in an article entitled "Electronic Ignition reconsidered."

More recently, the rising costs of car maintenance and petrol have caused an increase in demand from our readers for an upgraded CDI design. So we set about coming up with a new unit which would provide reliability while reducing the total number of parts to a minimum.

A complex design has to be avoided as far as possible because apart from increasing the cost, complexity generally means increased chance of component failure. Of late, the author has seen some designs which seem so complex as to be ludicrous if the consequences of component failure were not so serious.

Our approach has been to upgrade the design featured in August, 1970. This was and still is a very popular design because of its simplicity, but it has been plagued by a number of problems which we hope have now been ironed out.

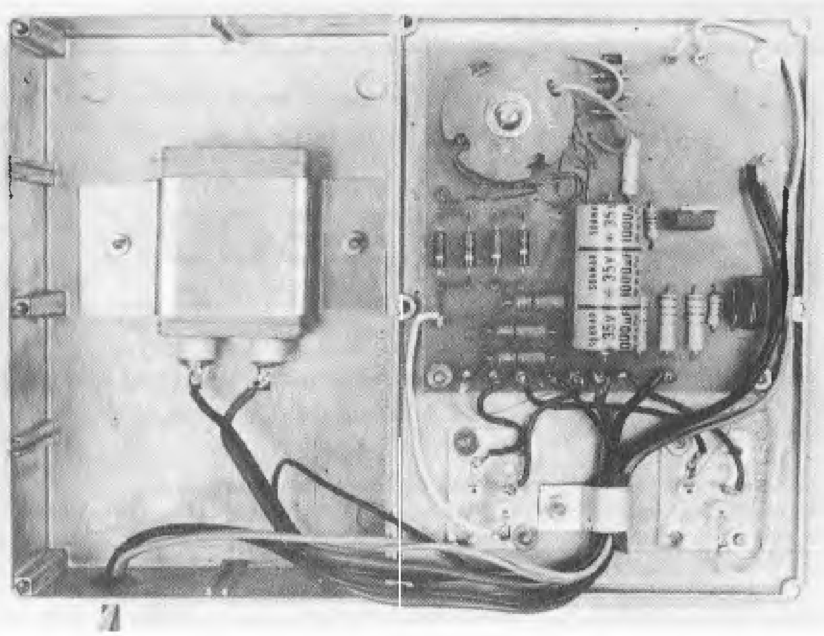
All circuitry in the new unit is accommodated on PC board measuring 10cm square. Besides simplifying construction and producing a more photogenic unit, the PC board reduces point-to-point wiring and the consequent risk of open-circuit connections. If you do decide to construct this unit, we strongly recommend using the PC board. In fact, take all possible care in assembling this unit since its reliability could be a matter of life and death.

Perhaps the first task to be undertaken in construction of the unit is to drill the necessary holes in the lid of the diecast case. We used an STC case measuring 172 x 120 x 55 mm but the Eddystone equivalent would be just as suitable, even though it is longer.

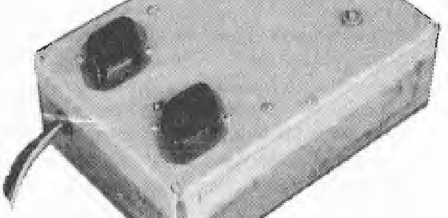
Both the PC board and the power transistors are mounted on the lid of the case. Use the PC board as a template for drilling the mounting holes. Similarly, use the mica washers for the power transistors as templates for the transistor mounting holes.

We also recommend that McMurdo TO-3 sockets (part number 2826-01-01) be used for the power transistors, because they result in more secure solder termination of the transistor leads. The transistors are secured to the sockets using self-tapping screws of an appropriate size.

Securing holes for the transistor sockets and the holes for the base and emitter of each of the transistors should be ⅛in diameter, while the holes for the self-tapping screws should be 3/16in diameter for adequate clearance.



TO-3 sockets are used for the power transistors to ensure trouble-free connections.



The inverter transformer uses two FX2242 ferrite core sections and a DT2180 Delrin single section bobbin, as supplied by Elcoma. At least one kitset supplier, Dick Smith Electronics, sells the bobbin with the 375-turn secondary wound on—which considerably simplifies the winding task.

If your bobbin is not supplied prewound, proceed as follows: wind the secondary with the aid of a hand drill clamped in a vyce. Two large flat washers (which can be made of Masonite), a long bolt and nut can be used to clamp the bobbin while the bolt is held in the drill chuck.

The washer next to the drill chuck should be suitably notched to allow the winding start to lay flat along the chuck during winding. The secondary uses 375 turns of 32 B&S double tough enamel (DTE) copper wire which eliminates the need for insulation between layers of the winding.

Begin by soldering the start of the winding wire to a 3in length of 5/.0076 (or similar) PVC hookup wire. Lay this across the width of the bobbin and anchor it with a short length of electrical insulation tape. Wind on 375 turns as evenly as possible. Cover this with two layers of insulation tape and terminate the finish in the same way as the start.

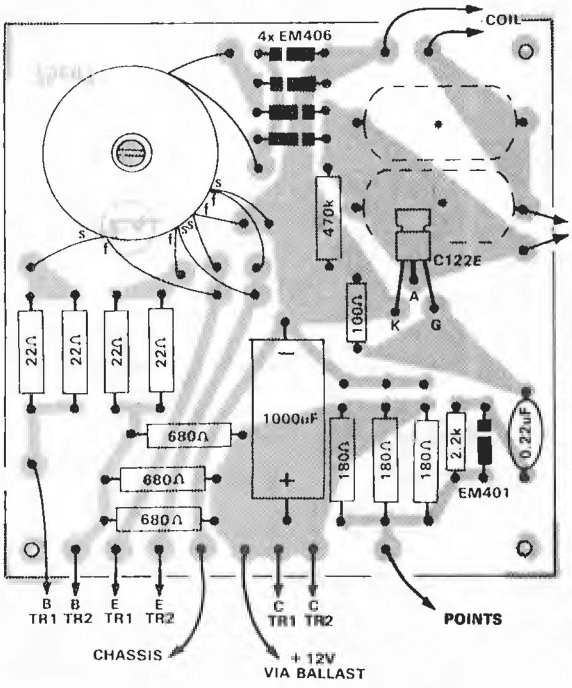
Leads for the primary and feedback windings need not be terminated as for the secondary—just leave the starts and finishes of the windings about six inches long, and cover with spaghetti sleeving. The starts and finishes should be securely anchored on the bobbin with insulation tape. The feedback windings are wound over the secondary, and the primary winding last. Both feedback and primary windings are wound bifilar, ie., both sections of each winding are wound simultaneously, with two wires together wound as one wire.

Use 28 B&S enamelled copper wire for the feedback winding (6 turns bifilar) and space the turns out to occupy the full width of the bobbin. The 13 turn(26 B&S)primary winding should be wound in the same direction as the feedback winding. Start and finish of each winding should be labelled S(start) or F(finish).

Finally, finish the winding with a couple of layers of masking tape to anchor it. (Insulation tape tends to unravel.)

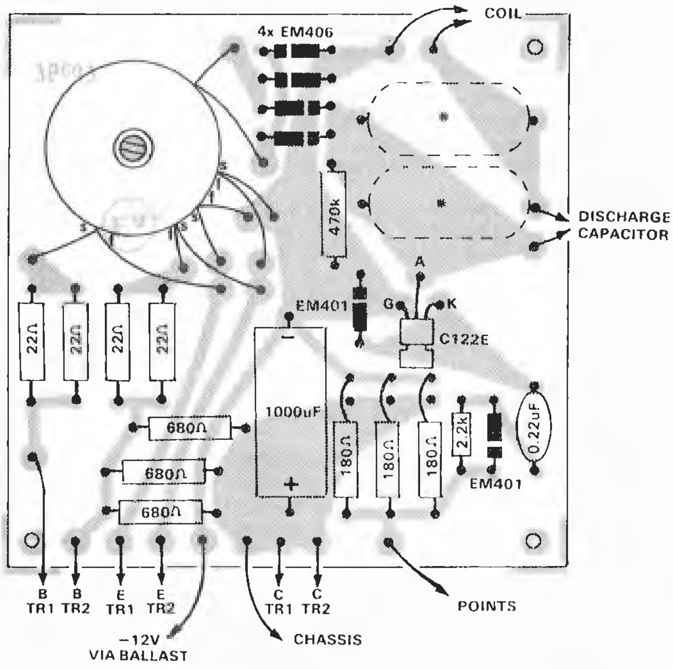
Place the completed bobbin in the two cup core halves, making sure that the core faces are clean before clamping. If there is dirt on the faces, the cores may crack when clamped, or the converter may squeal excessively and the transistors overheat.

We are of the opinion that it is unnecessary to impregnate or "pot" the transformer winding. For impregnation to be an effective guard against corrosion in the windings due to moisture, all the moisture must first be removed. Impregnation or pottings, as done by amateurs without access to vacuum apparatus, does little more than lock moisture in. In any case, the heat produced during normal operation of the

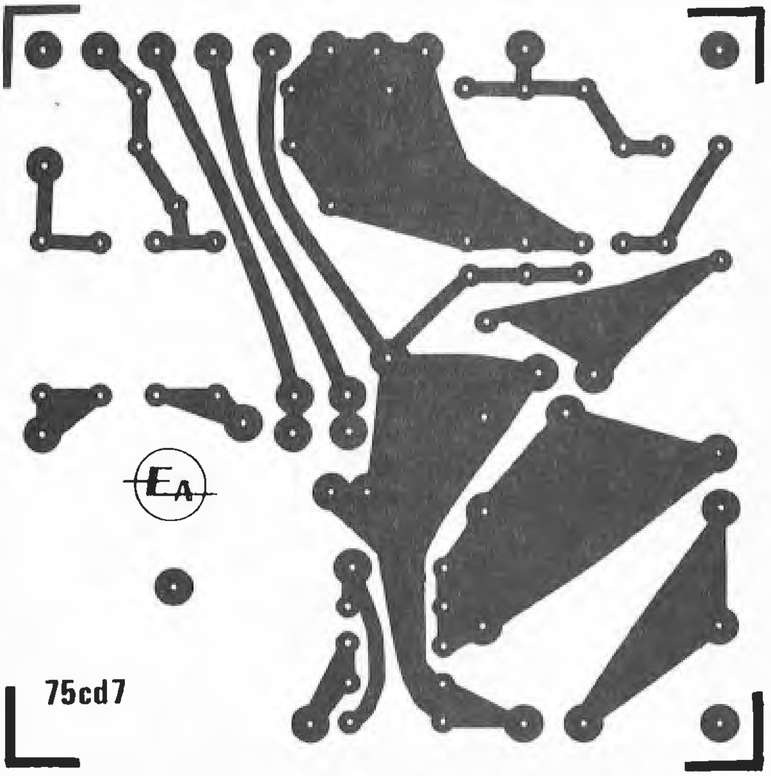


NEGATIVE CHASSIS

*
SEE TEXT



POSITIVE CHASSIS



PARTS LIST

1 STC diecast case, 172 x 120 x 55mm.
2 FX2242 ferrite cup cores.
1 DT2180 Delrin former.
2 2N3055 silicon NPN power transistors.
4 EM406/BY127/600 silicon power diodes.
1 EM401 silicon diode.
1 C122E silicon controlled rectifier.
CAPACITORS
1 x 1000uf/35VW electrolytic capacitor.
1 x 1uF/1kV paper capacitor, Ducon 5510A.
1 x 0.22uF/100VW metallised polyester capacitor.
RESISTORS (5 or 10% tolerance).
1 x 470k/1W, 1 x 2.2k/½W, 3 x 680 ohms/1W, 3 x 180 ohms/1W, 1 x 100 ohms/½W, 4 x 22 ohms/1W.
1 PC board 100mm square, 75cd7, 2 McMurdo TO-3 sockets, part number 2826-01-01
2 McMurdo TO-3 covers, part number 9151-09-01.
2 TO-3 mica washers.
13 PC stakes.
2 eyelet/solder lug assemblies (see text).
MISCELLANEOUS
Double-tough enamelled copper wire (26, 28 and 32 B&S), spaghetti sleeving, masking tape, epoxy adhesive, grommet, solder lug, pop rivets, screws, nuts, lockwashers, 4 ⅜in x No 6 self-tapping screws for TO-3 sockets, ½in x No 10 self-tapping screws for unit mounting, bracket for discharge capacitor, 23/.0076 figure-8 cable, cable clamp, solder, silicone grease or heatsink compound.

unit should serve to keep moisture out of the windings.

The transformer is secured to the board by the clamp screw, which should be 3/16in diameter and 1½in long. Use washers on the screw head side of the core and underneath the clamp nut, so that the board is not cracked. The clamp screw also secures the PC board to the lid of the case, along with the three other screws.

Strip the enamel insulation from the wire ends and terminate according to the circuit diagram. This done, the remaining components can be mounted on the PC board.

Note that R1, R2, R3 and R5 are parallel combinations of 1 watt resistors. This was done for two reasons: (a) they are cheaper than equivalent wirewound resistors and (b) their surface temperature rise is not as great as equivalent wirewound types. Some wirewound resistors become so hot as to char the PC board, even when they are considerably derated.

R4, 470k, is also a 1 watt resistor in order to obtain an adequate voltage rating (500V). ½W resistors have only a 350V rating.

IRH type GL1 metal glaze resistors are the recommended 1W resistors for this unit, with carbon film types being second choice. The GL1 resistors are rated at 1 watt up to 70 degrees Celsius (ambient) and have a low surface temperature rise.

The rectifier diodes should have a rating of at least 600 volts or higher. Those recommended are EM406 or BY127/600.

The recommended SCR is the General Electric plastic encapsulated C122E, which has a repetitive peak blocking and reverse voltage rating of 500 volts and a high dv/dt rating of 50 volts per microsecond (typical). It has the advantage that it can be soldered directly to the PC board and does not require a heatsink. We do not recommend any alternative SCR.

Note that the orientation of the SCR is reversed in the positive chassis version. In both versions, the SCR leads are splayed apart to fit the PC board.

The discharge capacitor presents us with a dilemma as far as component specifications are concerned. The ideal capacitor to use is the Plessey Ducon 5S10A which has been specifically designed for high discharge current applications. This is shown in the photograph of the prototype and is specified in the parts list.

We understand, however, that these capacitors are quite expensive and are often difficult to obtain.

The only alternative which is readily available is to use a 1uF (or two 0.47uF units in parallel) polycarbonate capacitor. Now if the specifications of these capacitors are taken at face value then they are just not suitable for this application. But at least one kitset supplier indicates that he has sold over one thousand CDI kits with polycarbonate capacitors and he has not had a single complaint.

Further evidence in their favour: We have bench-tested this CDI using polycarbonate capacitors under quite stringent conditions (at very high spark rates and at case temperatures up to 80 Celsius) and we were not able to record a single failure or deterioration in performance.

So while we would prefer to see the 5S10A capacitor as the one used by all constructors, it does seem as though polycarbonate capacitors (with a minimum rating of 630VW) are a viable alternative and we have made provision for them on the PC board.

If you do use a polycarbonate capacitor, it should have a voltage rating of at least 630VW.

The 1000uF/35VW electrolytic capacitor should be firmly secured to the PC board with an Epoxy adhesive such as Araldite. If this is not done, there is a danger that the weight of this relatively bulky component will cause the leads to break as it will be subjected to acute vibration.

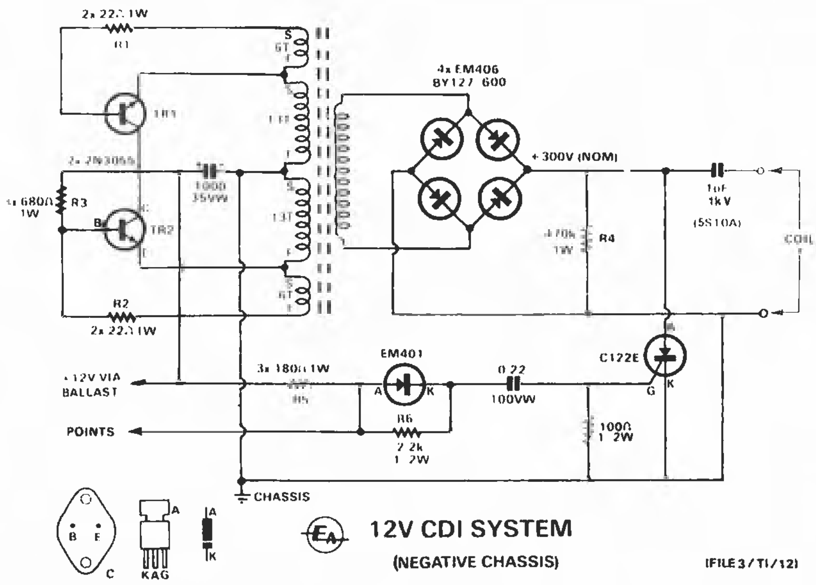
PC stakes are used for external connections to the PC board. Any type may be used, provided they are a tight fit in the PC board holes before soldering. When terminating wires to the stakes, wrap the stake securely with the wire and then solder.

Use pop-rivets and washers or screws, nuts and lockwashers to secure the McMurdoTO-3 sockets. Before mounting the transistors, ensure that the contact area is completely smooth and free of burrs and swarf. Smear the contact surface and the underside of the transistors with silicone grease or heatsink compound. If you are building the negative chassis version you will need to use a mica washer for each transistor to isolate it from the case.

We used TO-3 transistor covers from McMurdo (part number 9151-09-01) to eliminate the possibility of short circuits where tools are inadvertently dropped onto the transistor cases. The covers may be omitted in the positive chassis version.

When mounting the PC board on the lid of the case do not neglect to use lockwashers under all nuts, otherwise everything will rattle loose within the first few kilometres.

A suitable bracket will have to be made to mount the oil-filled discharge capacitor on the floor of the case. Connecting wires from the capacitor to the PC board and from the CD system to the rest of the vehicle should be



12V CDI SYSTEM

(NEGATIVE CHASSIS)

(FILE 3/T1/12)

HOW THE CIRCUIT OPERATES:—

The converter consists of two silicon NPN power transistors in a transformer coupled oscillator. Self-starting under full load conditions is assured by the asymmetrical biassing provided by R3. Operating frequency is about 3kHz.

The square wave voltage impressed across the primary windings appears across the secondary winding multiplied by the turns ratio and is rectified by a bridge rectifier to produce 300 volts DC with a 12V DC input. The 1uF discharge capacitor is charged from the rectifier via the primary of the ignition coil.

A silicon controlled rectifier (SCR) is used to discharge the 1uF capacitor and thus apply the full 300 volts DC to the ignition coil primary. The coil then acts as an "impulse transformer" to fire the spark plug.

The spark plug firing voltage is set by the plug gap and the gas pressure inside the cylinder and so is independent of the type of ignition system used. But since the energy applied to the ignition coil primary is much higher than in the conventional system and the "rise time" is much faster, the spark energy is greater and the chance of plug misfire is correspondingly less.

While the 1uF capacitor is being discharged, the converter stops functioning because it is effectively loaded down by a short-circuit. The converter does not restart until the SCR reverts to the non-conducting state. It then recharges the 1uF capacitor very rapidly. In fact, the capacitor is recharged to better than two-thirds of the final voltage in the first two cycles of converter operation.

Because of the square converter waveform and the rapidity with which the discharge capacitor is recharged there is a risk that the SCR can spontaneously break over into conduction due to the mechanism known as "dv/dt switching". To avoid this possiblity we specify an SCR with excellent dv/dt ratings and ensure that the gate is tied to the cathode via a low impedance path.

In the negative chassis version, this low impedance is set by the 100 ohm resistor R7 while in the positive chassis version it is provided by the series diode in the cathode circuit of the SCR.

The 470k resistor R4 is incorporated to prevent spikes from the converter charging the capacitor to higher than the nominal voltage when the motor is merely idling. It may be said to improve the load regulation of the converter. Resistor R4 is specified as 1W in order to provide a 500V rating.

Readers familiar with the original version of this circuit will note that it has a lower output voltage than the original: 300 vs 400. This has resulted largely from using a lower value of R3 than was originally specified which effectively damps the spikes and their energy content in the output waveform.

Positive trigger pulses to the SCR are generated in the following manner. When the distributor points are closed, current flows through R5. When the points open, the junction of R5 and R6 is suddenly raised to the full 12V and the associated diode charges the 0.22uF capacitor to 12V via the SCR gate and parallel resistor R7. This fires the SCR and discharges the 1uF capacitor. The trigger network is then inoperative until the points again close which enables the 0.22uF capacitor to discharge via R6. The choice of R6 is a compromise between obtaining an effective short discharge time for the 0.22uF capacitor, and thus allowing a high spark rate, and points bounce suppression.

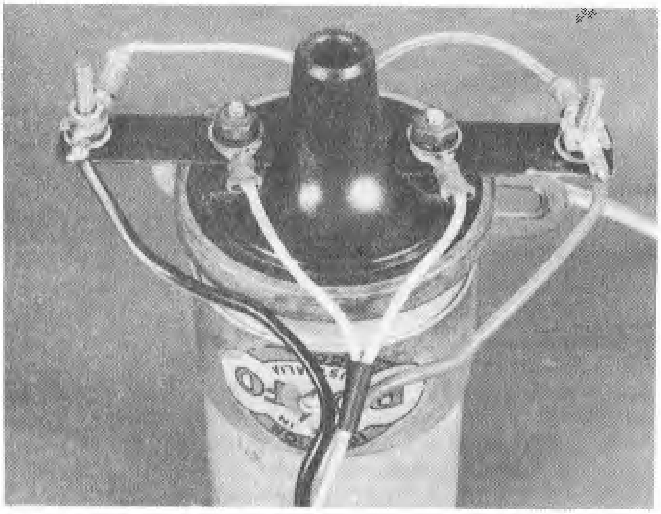
The choice of R5 (which is three 180 ohm resistors in parallel) is also a compromise between adequate points "wetting" current on the one hand and power dissipation inside the CDI case on the other.

The trigger circuit for the positive chassis version is a cunning variation of the negative chassis version. Here, when the points open, the junction of R5 and R6 is rapidly taken negative and the 0.22uF capacitor charged to 12V negative via the SCR cathode and gate. Thus, although the gate is tied to chassis, it is effectively raised above the cathode because the cathode is "pulled" negative. Thus the SCR triggers.

of reasonably heavy current capacity, such as 23/.0076 figure-8 cable or heavier.

When assembly of all components in the case is complete and all connections double-checked, its operation can be tested, before being installed in the car.

Operation can be checked without having a coil connected by substituting a 100 ohm resistor. On no account should the coil connections be merely bridged out with a jumper wire. If the discharge capacitor is energised in this situation and the SCR is inadvertently triggered, the resultant short-circuit discharge current will destroy the SCR.



At left is a mockup of a typical coil connected to the CDI system using two eyelet-solder lug assemblies. Those supplied in kits will be somewhat more robust than shown here.

Energise the converter from a 12V battery. (At this stage we should remark that some regulated power supplies will give misleading results when used with converter loads.) With the converter energised, the transformer should emit an audible whistle and the voltage across the discharge capacitor should be close to 300 volts DC.

If the converter does not "burst into song" when energised, check the transformer connections and swap around if necessary.

If the converter output voltage is above 300V by more than ten percent when using a 12V battery (which actually measures 12V) then there is a fault condition. For example, if the output voltage is 500 volts DC or more, there is a strong possibility that one of the transformer connections is open-circuit and/or one of the transistors defective.

Under these conditions, the transformer operates in a "spurious" ringing choke mode which if allowed to continue can cause the failure of the remaining transistor and the SCR.

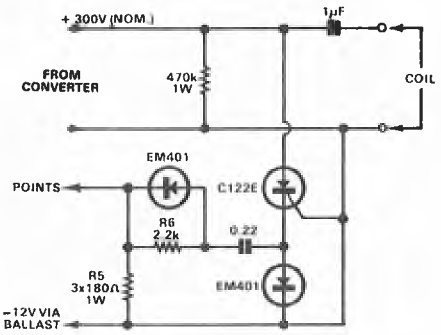
Another possible cause of higher than expected output voltages (say 350 to 400V) is that the 1000uF/35VW capacitor is partially or completely open-circuit or perhaps incorrectly polarised. The first possibility is easily checked by bridging with a known good capacitor.

Note that the converter output voltage is directly proportional to the battery voltage: At 12V in, output is 300V DC; at 16V in, output is 400V DC.

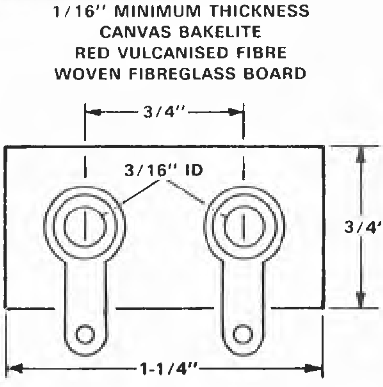
Operation of the SCR trigger circuit cannot be checked at this stage unless the 100 ohm resistor substituting for the coil primary has a rating of several watts.

Current drain of the converter is about 500mA at idle while the SCR trigger network resistors (3 x 180 ohms in parallel) set the current through the points at 200mA.

Having tested the converter for correct operation, the CDI system may be installed in the car.



An interesting variation is used for the positive chassis trigger circuit.



EYELET/SOLDER LUG ASSEMBLY

Two of these eyelet-solder lug assemblies will be needed for connection to the coil.

In the light of past experience, we do not recommend the use of octal plugs to enable changeover from CDI to normal operation. Contact resistance in these plugs can develop after a period of time and cause intermittent operation. For the same reason, we frown on those designs we have seen using push-button or slide switches for the changeover function. Slide switches are particularly dicey in this regard because mere vibration can shift the "slide" to a point midway between the two settings.

We favour a system of changeover whereby the original vehicle wiring is left unaltered. To this end, we have arranged with Watkin Wynne Pty Ltd to make available an eyelet/solder lug assembly which accommodates the existing wiring to the coil and the additional wiring from the CDI system.

As shown in the photograph of a mock-up coil installation, an eyelet/solder lug assembly is attached to each terminal post of the coil and the wires from the CDI system are soldered to the lugs. Thus the two coil wires from the CDI system are terminated at the coil terminal posts and the outrigger terminals remaining are used to connect the 12V supply (via ballast) to the CDI and the points wire to the SCR trigger network.

With this arrangement, it is easy to restore the vehicle to the original ignition system if the CDI has to be removed, as in the case when the car is sold.

For those who wish to make up their own eyelet assemblies, the material we recommend is canvas reinforced bakelite, red vulcanised fibre (as used for making washers) or woven fibreglass board (similar to that used in PC copper laminate). Minimum thickness of material is 1/16 inch. The eyelets should have an internal diameter of 3/16 inch or to suit the terminal posts of the coil in the vehicle.

There is no need to run an extra wire from the ignition switch to bypass the ballast resistor (or ballast wire in many vehicles). The voltage drop across the ballast resistor due to the converter current drain (the resistor is typically about 1 ohm) is fairly modest and does not impair the CDI operation. Even at high spark rates where the converter current increases, the battery voltage tends to rise anyway because of high generator speed and thus compensates to some extent for the ballast losses.

Painting the case black is optional. It is doubtful whether painting the box would improve heat transfer.

Installation of the CDI unit may prove to be a problem in many cars as space can be very limited. The unit should be kept as far away as possible from the heat of the exhaust manifold and should not be mounted low down where it will often be splashed with water. if space can be found, a position either left or right of the radiator, where there is good airflow, is just about ideal.

On some cars, the only space to mount it will be on the firewall. If this is the position decided upon the CDI case should be mounted on a pad of asbestos or polystyrene foam, to avoid its annoying whistle being radiated into the passenger compartment.

If the unit is mounted on a flat surface, it can be attached simply by drilling three or four holes through the floor of the case and through the associated panel and secured with self-tapping screws. If mounted on a curved surface, suitable brackets will have to be fabricated.

Make sure that the CDI case is solidly connected to the car chassis because it forms the electrical path for the converter current drain and the SCR trigger current.

Spark plug and points gap settings should be set as for conventional ignition. Using a wider spark plug gap will increase the tendency for the insulation of the coil and spark plug leads to be broken down, and will render the system inefficient if changeover to the conventional system is needed.

All spark plug cables and connectors should be in good condition and care should be taken not to have individual cables too close to each other to the engine block or head. It may even be necessary to make spacers for the cables using a material such as Paxolin or SRPB (synthetic resin paper board). This last measure will almost certainly need to be employed if the car runs erratically due to cross-fire or cable breakdown.

TVRS (television and radio suppression) ignition cables should be replaced with standard cable if their resistance is much above 20k per lead, as checked with an ohmmeter.

Music students — build this

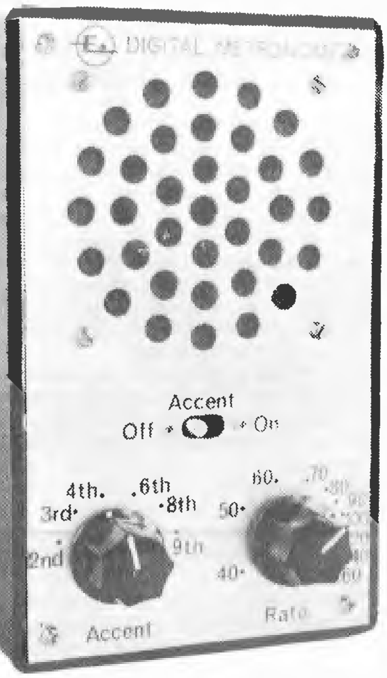
Digital Metronome with accented beat

Here is a project that music students should welcome—a new solid state metronome with an accented beat. Based on modern integrated circuit technology, our new Digital Metronome is simple to construct, and should prove reliable in use.

by DAVID EDWARDS

It is almost ten years since we last described an electronic metronome: in the May 1967 issue, to be precise. This unit was based on a unijunction transistor oscillator. The accented beat was produced by developing a "staircase" waveform, which was then used to trigger a second unijunction transistor which provided the accent. Interested readers are referred to this article for a more complete explanation of the circuit operation, and also for some background information on metronomes in general.

Before discussing our new metronome in detail, we will first give a short summary of the features and facilities which are desirable in a metronome. First and foremost, the rate at which its output clicks occur should be constant and repeatable. In other words, the clicks should come at regular intervals, and it should be possible to set the unit to operate at a particular rate with a good degree of certainty.



At left is a photograph of the completed metronome. Note the calibrated scale, which is reproduced elsewhere in the article.

Secondly, the clicks produced must be of the right intensity, and they must not be "musical" in character at all. This is most important. Thirdly, the basic rate must be adjustable within the normal musical tempos, which range from about 40 beats per minute (bpm) to about 160 bpm.

An accent feature, if provided, should be easily set to the normal musical requirement, such as one beat in every two, one in three, and so on. The accented beat should occur at the time when the normal beat would have occurred; i.e., it should not be delayed at all.

Having in mind the specifications as outlined above, and spurred on by a reader's query concerning the previous metronome, we set about designing a modern replacement. Our first idea was simply to replace the unijunction transistors with 555 type integrated circuit timing modules, generating the accented beat by means of a staircase waveform as before.

This approach, however, proved to have several disadvantages. While the basic oscillator was satisfactory in terms of stability, the output pulse did not seem to produce the right type of click. If the oscillator was adjusted so that a very narrow pulse was produced, the resultant click was too soft, and could not be clearly heard. Lengthening the output pulse with the idea of giving it more energy meant that we now heard two separate, but closely spaced clicks.

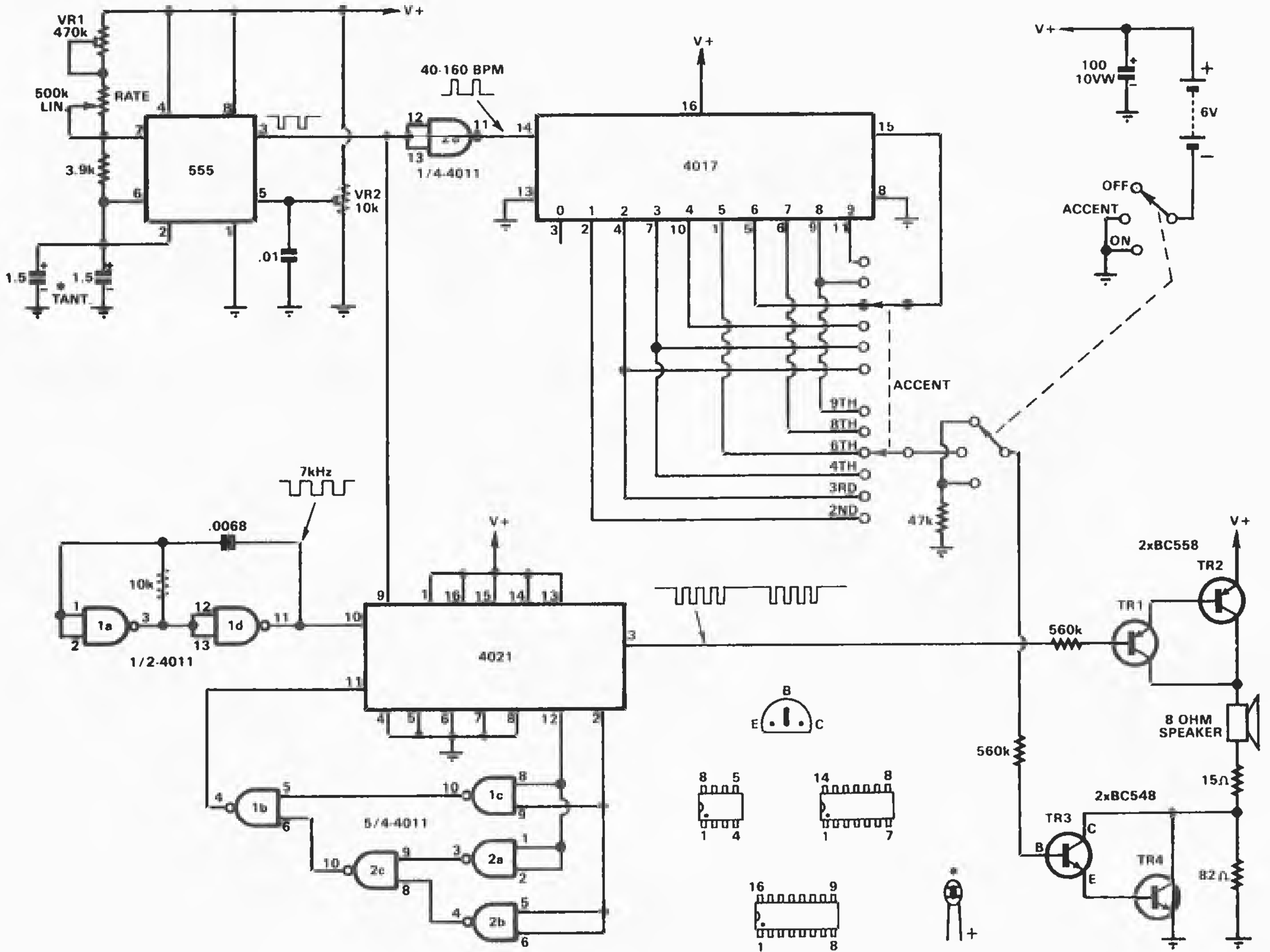
Our thoughts then turned towards using the pulse to gate on some type of oscillator or noise source. This presented its own difficulties, however, as we now discovered that the accented pulse did not start till part way through the normal pulse, giving an effect which we can represent graphically(or is it textually?) as "accENT", rather than "ACCENT".

It was this problem that led us to the present unit, which uses digital logic chips to generate an accented pulse starting at the correct time, as well as a digital noise source. We have retained the 555 type oscillator as the basic drive unit.

Turning now to the circuit diagram, we can follow its operation step by step. Power is supplied by four AA cells in series, giving a 6V rail. This is shunted by a 100uF electrolytic capacitor.

The 555 is connected as a conventional astable oscillator. The width of the negative going output pulses is determined by the 3.9k and 3uF resistor-capacitor combination, while the spacing between pulses is determined by the 500k rate control and the 470k preset pot. The operating frequency can be trimmed by varying VR2, a 10k preset pot.

CMOS gates 1a and 1d are connected as a free-running oscillator, with a frequency of about 7kHz. This is connected to the clock input of a 4021 type 8-stage static shift register, which is used



DIGITAL METRONOME WITH ACCENTED BEAT

3/MS/-

as a seven stage pseudo-random noise generator, with the last stage serving solely as a buffer. We used a seven stage generator rather than an eight stage, because the required feedback gating is much simpler.

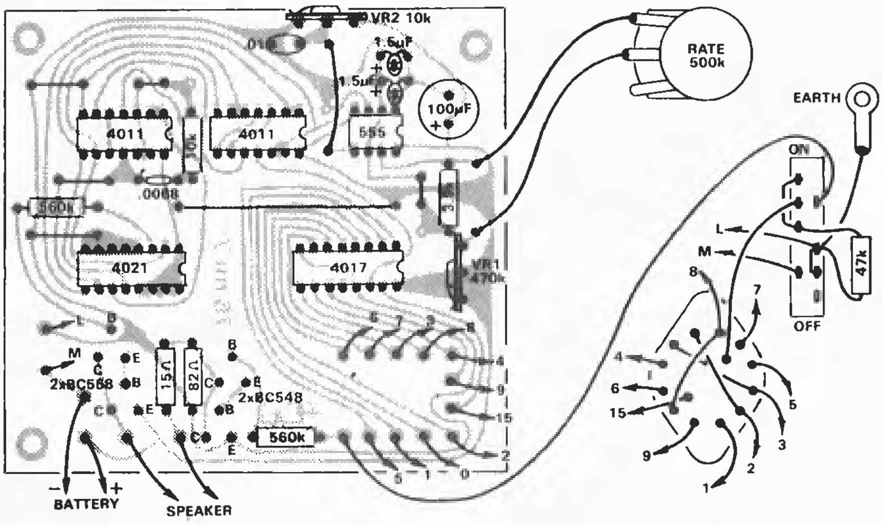
Feedback to the input, pin 11, is generated by gates 1b, 1c, 2a, 2b and 2c, which perform the exclusive nor function on the outputs from the sixth and seventh stages. This causes the register to cycle through 127 different patterns, before it repeats, and gives a pseudo-random stream of high and low pulses from the last stage.

This stream of "noise" is gated on and off by applying the output pulses from the 555 to the parallel load enable input of the 4021, pin 9. When the 555 output is in the high state (between pulses), the register is asynchronously loaded with the data presented at the parallel inputs. At the same time, the clock input is disabled, so the register does not shift.

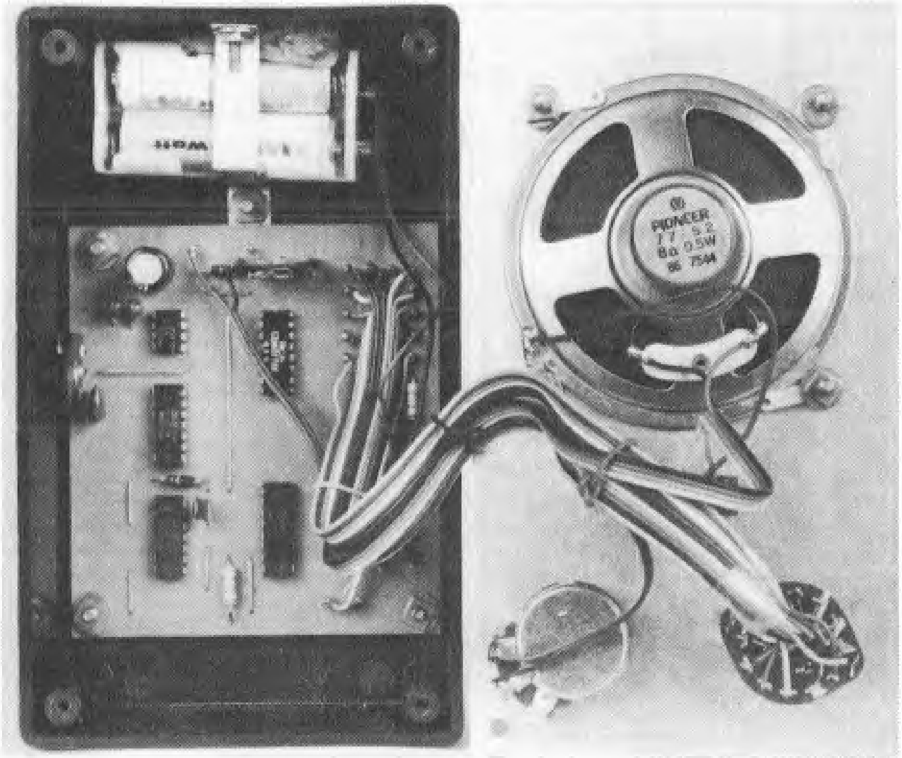
The number that is loaded into the register has been chosen as follows: Firstly, it must not be 00000001 or 00000000, as this will cause the register to lock into this sequence. The eighth stage must be loaded with a 1, so that the PNP Darlington pair controlling the speaker is held off. Keeping these two requirements in mind, the actual number chosen was 00001111, which minimises interconnections on the printed circuit board.

When the 555 output goes low, the register commences to shift, and the noise signal so generated switches the speaker on and off via the PNP Darlington pair TR1-TR2. It is necessary to use a Darlington pair to prevent excessive loading on the CMOS output stage. The speaker current, and hence sound intensity, is limited by the 15 and 82 ohm resistors.

The resulting burst of noise is exactly the type of non-musical signal required



This combined component overlay and wiring diagram will aid construction. Use rainbow cable to make the numbered connections.



This photograph shows the internal layout of the metronome. VR1 is at the top of the PCB, while VR2 is at the extreme left. Note the battery clamp. PC stakes have been used to facilitate the external connections to the PCB.

for a metronome. It can be clearly heard over typical musical sounds, yet does not itself conflict.

We have not used the MM5837 digital noise source IC (as featured in the 1975 Yearbook) to generate this noise because of the cost involved in the purchase of the IC, and also because of the dual power supply which this chip requires. Our alternative solution, while not as elegant, is quite satisfactory in this role, and is considerably cheaper.

The accented beat is generated by a second CMOS chip, a 4017 type divide-by-ten counter/divider with ten decoded outputs. Gate 2d is used to invert the pulse from the 555, which then clocks the counter. A two-pole six-position switch is used to connect the appropriate output pulse to the reset line, thus resetting the counter. The second pole of the switch is used to select the required output pulse.

We have used a six position switch as this is the largest commonly available rotary type, so that our metronome can only accent six beat patterns. We have chosen these to be the 2nd, 3rd, 4th, 6th, 8th and 9th, as we felt that these would be the most useful. If required, a larger switch could be used, and the remaining beats accented.

The signal from the accent switch then passes to one pole of the power switch, which is a three position miniature slide type. In the centre position, the signal is connected to the NPN Darlington pair TR3-TR4, which then shorts out the 82 ohm resistor for certain beats, thus providing the accents.

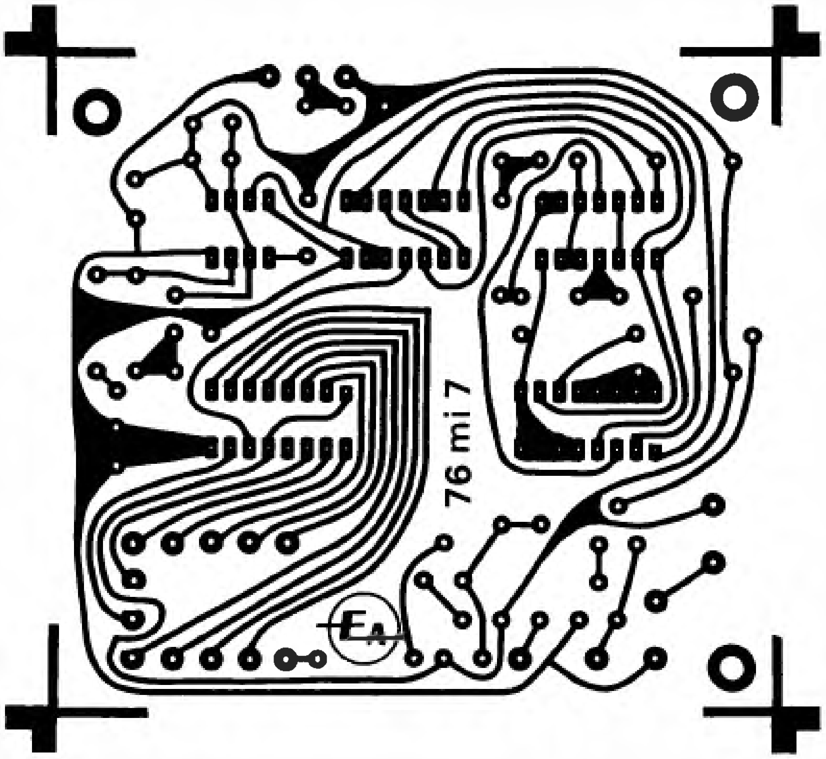
In the second "on" position of the slide switch, the base of the NPN Darlington pair is connected to ground, thus disabling the accent. The 47k resistor wired across the switch prevents the 4017 outputs from being shorted to ground as the power switch is operated.

After completing our prototype, testing showed that the device was suitable in all but one respect. We had not calibrated it. This was easily achieved, however, and required only the addition of two trimpots and the use of a stopwatch. We were then able to fit a calculated scale, and adjust the metronome to agree with it. The exact technique required is explained later in the artcle.

Construction of the Digital Metronome should be within the capabilities of most readers. With the exception of the switches, controls and speaker, all components are mounted on a small printed circuit board, coded 76mi7, and measuring 86 x 94mm.

We mounted the components in a small plastic utility box measuring 150 x 90 x 50mm. The aluminium lid is used as a front panel, with suitable labels applied using stick-on lettering. The batteries are held in a holder, and clamped to the bottom using a small scrap of aluminium. Mount the speaker behind the front panel, and drill a suitable pattern of holes. A cloth can be clamped between the speaker and the panel, to keep dust out.

Commence construction by mounting all components except the CMOS ICs on the PCB. The connections to the switches and other components not mounted on the PCB are made using "rainbow" cable



This is a full sized reproduction of the PCB pattern, shown from the copper side, which can be traced if desired.

and PCB pins. Use the component overlay diagram and wiring diagram to help you. The 47k resistor is mounted on the back of the slide switch, as shown.

The CMOS devices should only be mounted on the PCB when all other construction is finished. Make sure that your soldering iron tip is connected to the "earth" line of the copper pattern. Remove the ICs from their protective wrapping, and insert them in the board with a minimum of handling. The first pins to be soldered should be the power supply pins, which are at diagonal extremes of the chips (pins 8 & 16 or 7 & 14). If you are not confident of completing this successfully, good quality IC sockets may be used.

With the power switch in the off position, connect the battery, and then switch to the accent position. The speaker should start to click at a rate set by the rate control, and the accent should occur as set by the accent switch. Check that operation is correct in all positions of this switch. Any faults will most likely be due to faulty wiring at the switch. Check also that in the second on position, no accent occurs.

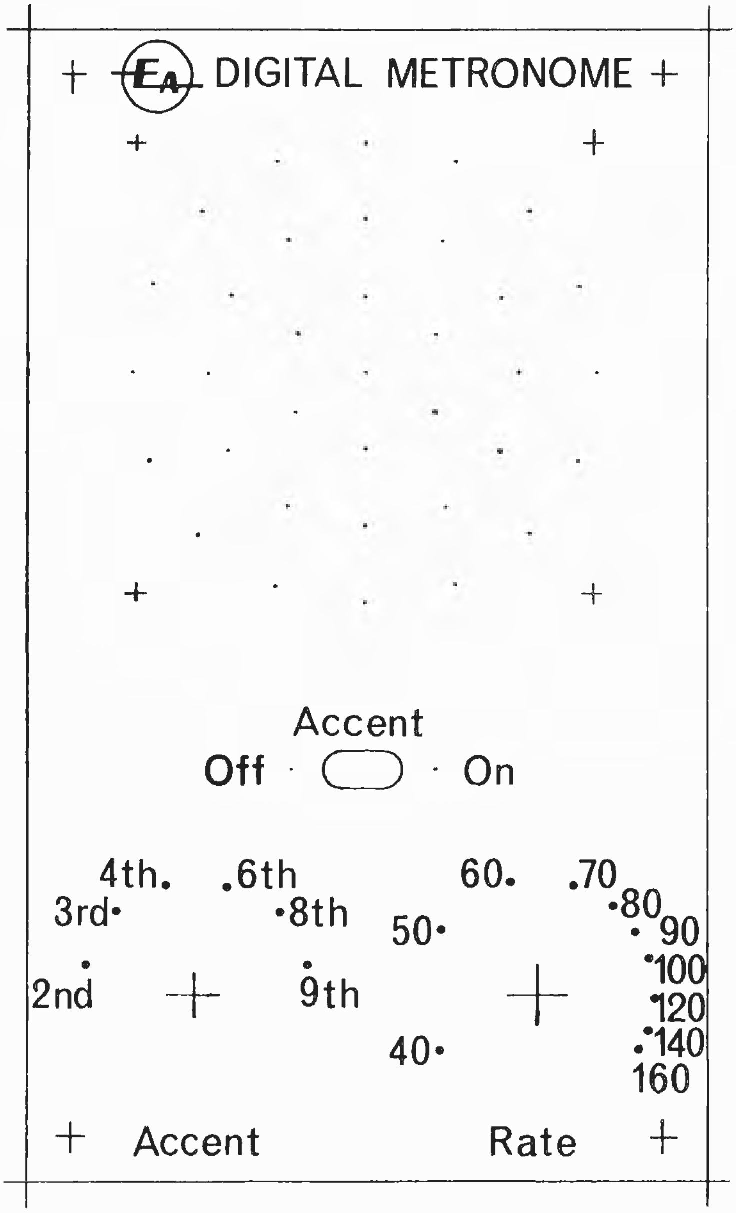
Calibration of the metronome can now commence. This requires a scale similar to that on our prototype. This can be copied from the full-sized photograph shown elsewhere in this article, or from a positive or negative dyeline obtainable from our Information Service for $2.00. Once you have copied the scale onto the front panel, fix the knob so that it can rotate equally past the 40 and 160 marks. There should be about 30 degrees of movement past both marks.

Now set the pointer to the 160 mark, and adjust VR2 so that the metronome produces 160 bpm. If you have access to a frequency counter, this can be used. Otherwise, it will be necessary to use a stopwatch or wristwatch with a sweep second hand.

You will find it easier to check this rate if you set the accent switch to accent every fourth pulse, and only count these accented ones.

Then set the pointer to the 40 mark, and adjust VR1 to obtain 40 bpm. Return the pointer to the 160 mark, and re-adjust VR2 for 160 bpm. Alternate between the two adjustments until both are correct. As a final check, set the pointer to 90, and see if the metronome produces 90 bpm.

Your Digital Metronome is now complete. Replace the batteries when the calibration is no longer accurate. After installing the new batteries, check the calibration, and adjust as necessary.



This full sized copy of the front panel can be used directly, or it can be copied. It is the correct size for the UB1 box.

PARTS LIST

SEMICONDUCTORS

1 CD4017C divide-by-10 counter/divider
1 CD4021C 8 stage static shift register
2 CD4011C quad 2-input gates
1 555 timer IC
2 BC548 NPN transistors, or equivalent
2 BC558 PNP transistors, or equivalent

CAPACITORS

1 0.0068uF plastic
1 0.01uF plastic
2 1.5uF tantalum
1 100uF 10VW PCB mounting electrolytic

RESISTORS (all ½W)

1 15 ohm, 1 82 ohm, 1 3.9k, 1 10k, 1 47k, 2 470k 1 500k linear pot, 1 10k trimpot, 1 470k trimpot.

MISCELLANEOUS

1 2 pole 6 position rotary switch
1 2 pole 3 position slide switch
1 plastic utility box, 150 × 90 × 50mm, type UBI or similar
2 knobs
1 miniature 8 ohm speaker, 76mm dia max
1 printed circuit board, 86 × 94mm, coded 76mi7
4 AA cells, holder and clip to suit
Scrap aluminium, solder, hook-up wire, machine screws and nuts, circuit board pins

Note: resistor wattage ratings and capacitor voltage ratings are those used in our prototype. Components with higher ratings may generally be used provided they are physically compatible. Components with lower ratings may be used in some cases, providing ratings are not exceeded.

A dwell meter for engine tune-ups

This dwell meter should find ready popularity with Saturday-afternoon mechanics. It will prove handy for making ignition adjustments to your car, helping you to save on service costs and keep your car in a good state of engine tune. It's easy to build too, using just one IC and assembled on a small PC board.

by GREG SWAIN

Next to a tachometer and an ignition timing light, a points dwell meter is perhaps one of the most useful instruments that one could have on hand for engine tune-ups. A dwell meter will enable you to set the ignition points accurately, and also to check on points condition between tune-ups without taking off the distributor cap.

The circuit presented here is based on an application note in the latest "Linear Data Book" put out by National Semiconductor Corporation. All we have done is to make a couple of modifications to the original circuit and design a small PC board to make the unit suitable for home construction.

Before going into the circuit details though, let's first explain the term "dwell".

Simply stated, dwell is the number of degrees the distributor cam rotates, while the points are closed during each ignition cycle. Most mechanics (both "do-it-yourself" and "professional") set ignition points to the correct dwell angle by rotating the distributor cam until the points rubbing block rests on the top of the lobe, and then setting the gap between the points to a predetermined value with a feeler gauge.

In skilled hands, this method is generally considered adequate, although it does leave something to be desired. The problem is that it's a static test, rather than a dynamic one. If the points do not open with perfectly parallel surfaces, or if there is pitting of the surface or the feeler gauge is handled incorrectly, it is possible to miss the correct dwell angle by quite a number of degrees.

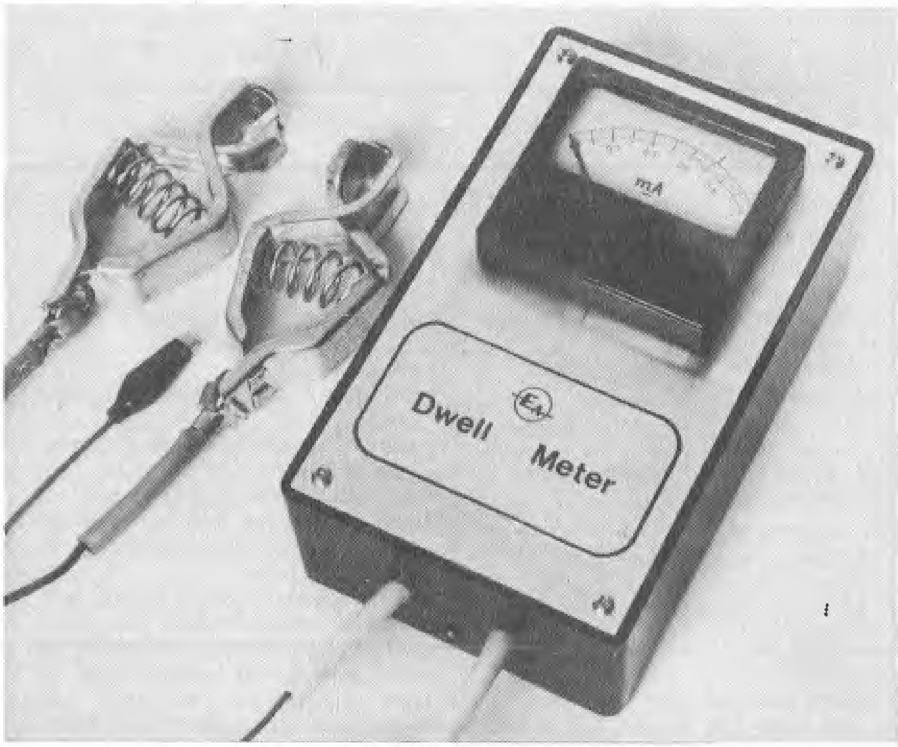
An electronic dwell meter which allows a reading of dwell angle to be made under dynamic conditions is the most effective means of overcoming these problems. The points gap is simply adjusted until a correct reading is indicated on the meter (or rather the reading falls within the manufacturer's specified range).

Proper dwell adjustment is important if we are to obtain the best possible performance from an engine. There are several reasons for this.

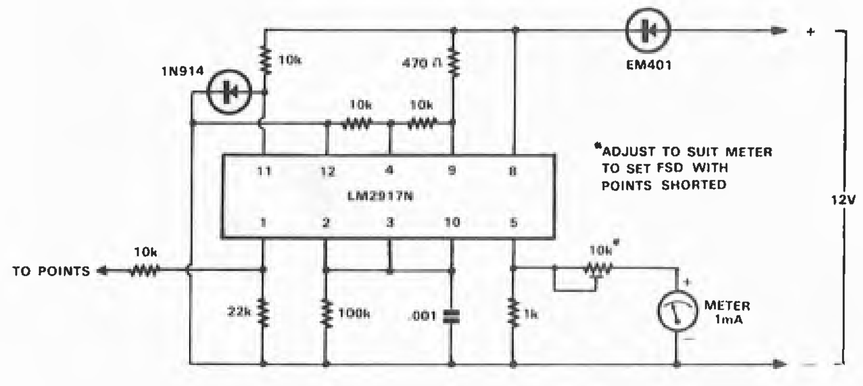
First, dwell affects ignition timing (although the converse is not true) and before carrying out timing adjustments it is necessary to set the dwell to the figure specified for the engine. On Holden 3300cc 6-cylinder engines, for example, this figure is given as 30-35 degrees. If the measured dwell is less than the specified figure the points gap must be decreased. If the reading is too high, the gap must be increased.

Another reason is that too small a dwell angle will result in the coil not reaching magnetic saturation at high rpm, with a consequent poor ignition through loss of spark energy.

To explain further, in the ignition system the spark for ignition is generated when the distributor points, which are in the coil primary circuit, are opened and the magnetic field in the coil collapses. This collapse is quite rapid and causes a high induced voltage in the secondary of the coil, firing the plug.



Our new dwell meter is suitable for 4-, 6-, or 8-cylinder cars. See text regarding the meter calibrations.



DWELL METER

3/TM/–

To prepare for the next spark, the distributor points must close and let the magnetic field build up again in the coil. This build-up of the magnetic field is not instantaneous, and if the distributor points do not remain closed for long enough it will not have time to build up to its maximum level. The result will be a low secondary voltage and a weak spark.

This phenomenon is particularly noticeable at high speed, and can cause misfiring. It can also make the engine harder to start, particularly in cold weather. For these reasons, it is necessary to allow the points to remain closed for as long as possible.

On the other hand, too large a dwell angle will produce sluggish opening, plus excessive arcing and pitting of the points at low engine speeds. It is also possible that the coil will not have sufficient time to discharge, again resulting in a weak spark and misfiring at high rpm.

A dwell meter is useful for diagnosing engine faults too. A change in dwell angle reading or a wavering of the meter pointer can mean one or a combination of several faults. A fluttering pointer at high engine speeds can indicate points bounce. Increased tension on the moveable-point spring can correct this fault. If the meter pointer wavers, the distributor cam shaft could be wobbling due to worn bearings, or the cam could be worn.

Let's now take a look at the circuit of our new dwell meter.

Heart of the circuit is a National Semiconductor LM2917N IC supplied in a 14-pin dual-in-line package (DIP). This is described by National Semiconductor as a monolithic frequency to voltage (F/V) converter with a high gain op amp/comparator. The op amp/comparator is fully compatible with the F/V convertor and has a floating transistor (collector and emitter uncommitted) as its output.

Other features of the chip include an on-chip zener regulator circuit and the ability to source or sink output currents of up to 50ma. Op-amp inputs are uncommitted and operating voltage is 6-28V DC.

Although the internal circuitry of the chip is relatively complex, the basic principle of operation of the circuit is relatively straightforward. The external pulsating DC signal derived from the points is applied to a differential amplifier driving a positive feedback flip-flop circuit. The flip-flop in turn controls a charge pump which charges or discharges an external .001uF capacitor between two voltage levels.

Since the capacitor's value is fixed and the supply rail constant, the pump current is directly proportional to the input frequency. The differential amplifier, flip-flop and charge pump thus constitute a basic F/V converter.

The output from the F/V converter section is coupled into the inverting input of an operational amplifier, wired here as a comparator with its non-inverting input biassed at approximately half the supply voltage. This in turn controls the output transistor, turning it on and off as the output from the comparator swings high (points closed) and low (points open) respectively.

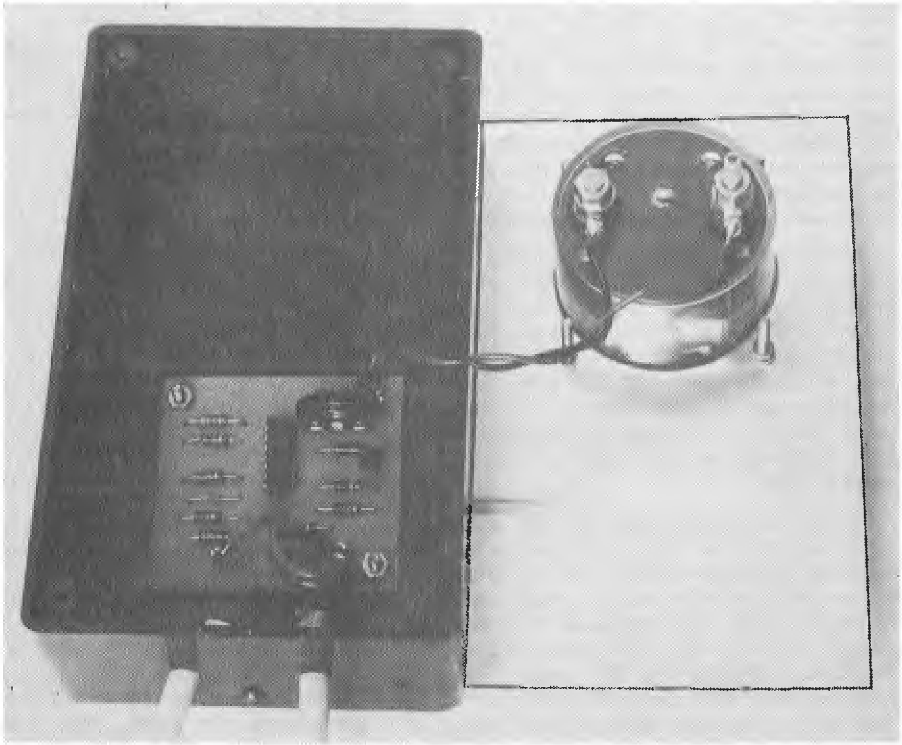
The output is taken from the emitter (pin 5) and applied to the meter through a 10k preset potentiometer. The pot. is adjusted to give a full-scale meter reading with the points shorted. Thus when the ignition points are open the meter reads zero and when the ignition points are closed the meter reads full-scale.

In practice, the ignition points are closed for only part of the time, so the meter will read only the average time they are closed. For example, if the closed and open times are equal, and if the pulses are of sufficiently high frequency, the meter will be deflected one-half of full-scale. Again, if the points have been set with a high dwell angle the average reading will be well up the scale. The reverse applies if the points have been set with a small dwell angle.

We assembled the circuit on a small PC board measuring 56 x 60mm, code 77d7. An overlay diagram showing the placement of components on the board accompanies this article. PC stakes were used to facilitate the five external connections to the board.

The diode in the positive supply line is a precautionary measure to protect the unit in the event of reverse polarity connection to the battery. It may be replaced

Below: inside the completed dwell meter. There is room to include the tacho circuit described on p46, if you wish.



on the board by a wire link if you feel it unnecessary, although we consider it to be cheap insurance.

A small plastic case with a light gauge aluminium lid houses the prototype dwell meter. Measuring 150 x 90 x 50mm, these plastic "zippy" boxes are available at low cost from a number of suppliers, including Dick Smith Electronics Pty Ltd.

Many readers will no doubt have a suitable chassis or case which could be used. If the chassis is made of metal it should be connected to the battery supply line which is normally connected to the vehicle chassis.

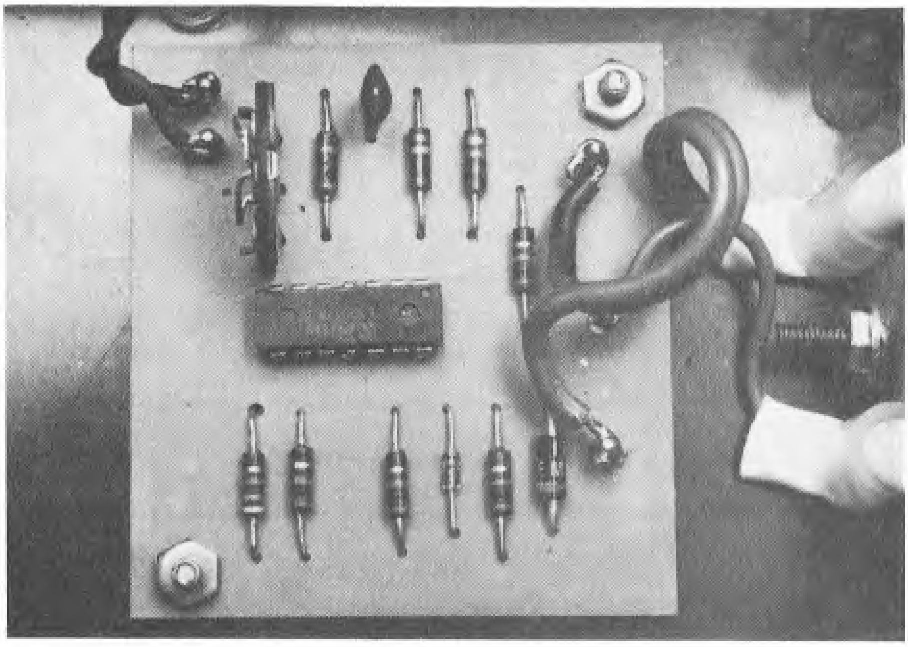
This latter measure prevents hash picked up by the metal chassis of the dwell meter from causing erratic and erronous readings. In some cases it may also be necessary to fit a 0.1uF bypass capacitor across the supply. Note that a small amount of needle flutter is normal at low idling speeds. If this is considered excessive a low value electrolytic capacitor may be added across the meter terminals.

One metre of two-core flex fitted with large alligator clips was used to make connections to the car battery, while a slightly shorter length of hookup wire fitted with an appropriate clip was used to make the connection to the points. These leads are entered through one side of the plastic case and should be securely clamped as shown in the photograph.

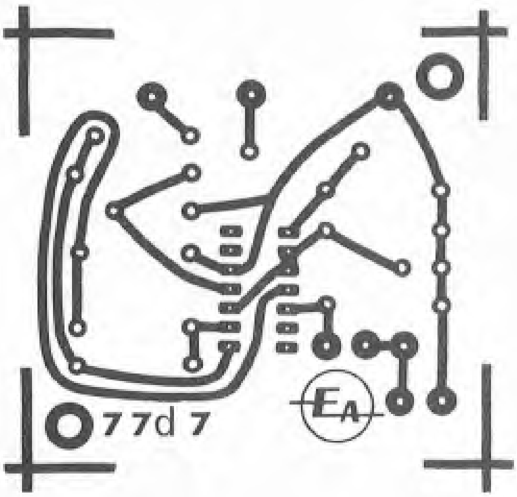
All that remains after assembly is the calibration procedure, which is fortunately quite straightforward. First mark the meter with a linear scale from 0-45° if have an 8-cylinder car, from 0-60° for a 6-cylinder car, and from 0-90° for a 4-cylinder car. Now connect the unit to the vehicle's battery, short the points lead the ground, and adjust the preset pot, so that the meter reads full scale. (Note: it is also normal for the meter to read full scale with the points lead open circuit).

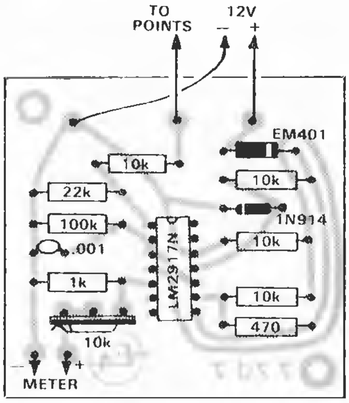
An alternative calibration method is to calibrate the meter from 0-60° and replace the preset pot. with a front panel "dwell calibrate" potentiometer. The dwell calibrate pot. is then adjusted so that the meter reads 60° (full scale) for 6-cylinder cars (points shorted) and 45° when used on 8-cylinder and 4-cylinder cars. Readings are then doubled for 4-cylinder cars.

Other calibration options are also available, and we leave it to readers to make up their own minds. For example, owners of 4-cylinder vehicles could well leave the meter calibrations as they are, simply adjusting the preset pot. so that the meter reads 0.9 or 90°. Again, the meter calibrations may be left as they are, the meter set to read full-scale, and a suitable table table relating calibrations to actual dwell values made up.



Above: a close up view of the assembled PC board. Below left is an actual size reproduction of the PC pattern, while at left is the component overlay diagram.





PARTS LIST

- 1 case, 150 x 90 x 50mm
- 1 PC board, 56 x 60 mm, code 77d7
- 1 LM2917N integrated circuit
- 1 1mA FSD meter movement
- 1 1N914 silicon diode
- 1 EM401 silicon diode
- 1 .001uF metallised polyester capacitor
- 1 metre of two core cable
- 3 alligator clips as required
- Solder, hookup wire, machine screws and nuts

RESISTORS
(½ or ¼W, 10% tolerance)
1 x 470 ohms, 1 x 1k, 4 x 10k, 1 x 22k, 1 x 100k
1 x 10k preset potentiometer

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used in our prototype. Components with higher ratings may generally be used provided they are physically compatible.

There is one further option available to the constructor, and that is to fit the tacho circuit described on page 46 of this project book into the same case. This tachometer was based on the Philips SAK140 IC, is low in cost and easy to build. The author can certainly testify to its value, and that together the two instruments make a very useful tune-up aid for the family car.

Simple, inexpensive TV accessory:

Remote TV headphones

If you like to watch TV late at night without disturbing other members of the household, this little gadget may be just what you are looking for. You listen to the TV sound using either an earphone or a pair of headphones, without being tied to the TV by a bothersome cord. No modifications are required to the TV set, and the unit is simple and economical to construct.

by DAVID EDWARDS

The unit to be described in this article also has a use as a TV hearing aid for people who are hard of hearing. With slight modifications, it is possible to arrange for such people to hear the TV sound channel at a level higher than would normally exist in the room. Of course, this could be done simply with headphones alone, but normally this requires the listener to be "tethered" to the set.

With the unit described here sound information from the TV is transmitted to a self contained receiver unit by magnetic induction. To do this, a loop of wire is required around the perimeter of the room in which the device is to operate. This loop is fed with the required audio signal, and generates a magnetic field in the interior of the loop whose intensity varies with the audio information.

The receiver consists simply of a second loop, whose output is fed into a suitable voltage and power amplifier. In order to improve the efficiency of energy transfer, while keeping the receiving loop to small dimensions, it is wound around a section of ferrite rod. This enables the complete receiver to be housed in a small mini-box, measuring only 83 x 54 x 29mm.

The circuit details of the receiver are shown in the accompanying circuit diagram. The pickup coil consists of five layers of 30 B & S enamelled copper wire, wound on a 75mm length of 9.5mm (⅜") ferrite rod. The exact number of turns is not critical, and neither is the size of the wire used.

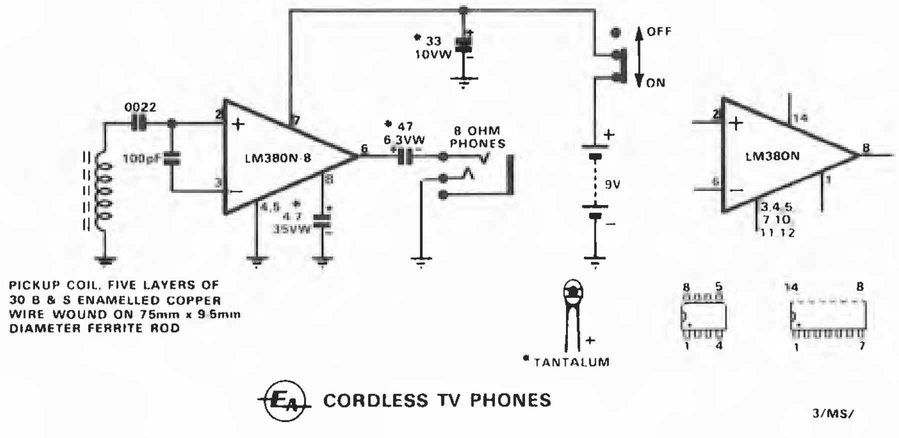
We have used an LM380 integrated circuit as the amplifier, as this gives a simple, reliable unit, using a minimum of parts. These devices have a fixed gain of 34dB, and are capable of driving an 8 ohm speaker or headphone directly. The output is short circuit proof, and incorporates thermal limiting. Either an 8 or 14 pin package is available.

We have tailored the input and output coupling capacitor values to limit the low frequency response of the receiver. This is required because of the large amounts of 50 and 100Hz hum and ripple which tends to be picked up by the loop. The 100pF capacitor connected between the inputs also rolls off the high frequency response above 5kHz, to prevent any stray 15625Hz TV line frequency signal from being passed to the headphones.

We have used tantalum capacitors for the supply decoupling and bypass units, as these are usually smaller than their aluminium counterparts. Power is supplied by a 9V battery, one of the 216 type units. A small slider switch is used as an on/off switch.

Construction of the unit should be within the capabilities of the average enthusiast, and does not require any specialized tools. We made up the transmitter loop using a 15 metre

BELOW: The circuit diagram of the receiver unit. Note the different pin connections of the two LM380 devices currently available.



PARTS LIST

- *1 LM380N or LM380N-8 audio amplifier*
- *1 47uF 6.3VW tantalum electrolytic capacitor*
- *1 33uF 10VW tantalum electrolytic capacitor*
- *1 4.7uF 35VW tantalum electrolytic capacitor*
- *1 0.0022uF polyester capacitor*
- *1 100pF ceramic or polystyrene capacitor*
- *1 length of 9.5mm (⅜") dia. ferrite rod*
- *1 earphone socket*
- *1 9V miniature battery and clip to suit*
- *1 plastic minibox, 83 x 54 x 29mm*
- *1 miniature slide switch*
- *1 length of multiconductor cable*
- *Veroboard, solder, 30 B & S enamelled copper wire, insulation tape, hookup wire.*

Can you afford not to know about microprocessors?

Six years ago, microprocessors and microcomputers were little more than dreams in the minds of research engineers and science fiction writers. Now they are changing the whole face of electronics. The change is happening so fast that overseas it is being called an explosion, a revolution. What are these new devices, and why are they having such a dramatic impact? Whether you're a professional or a hobbyist, you really need to know.

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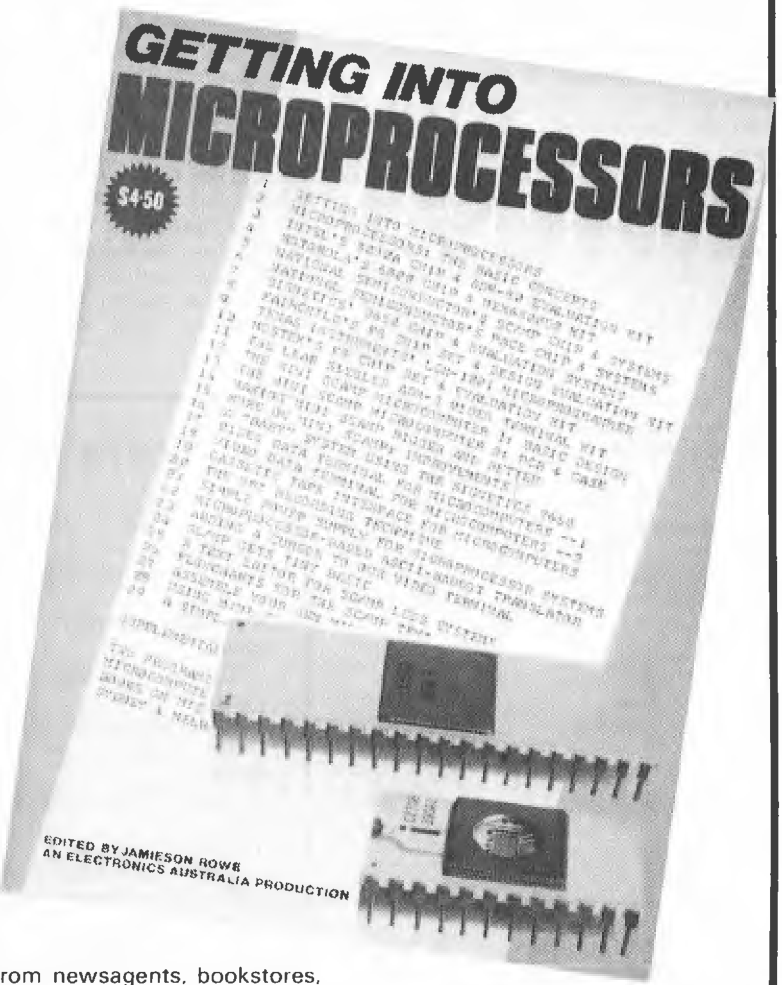

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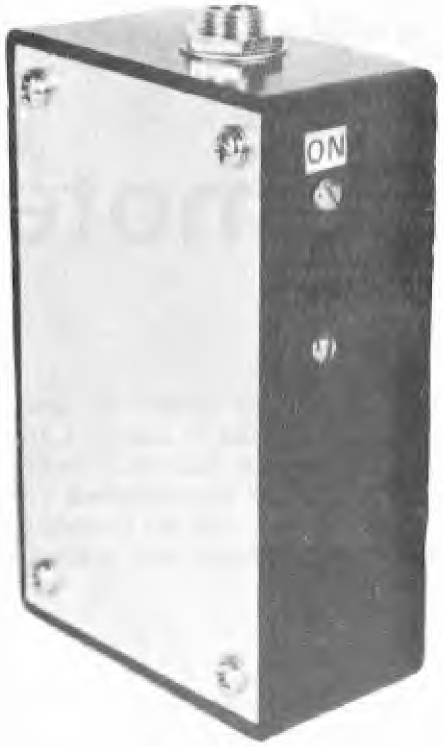


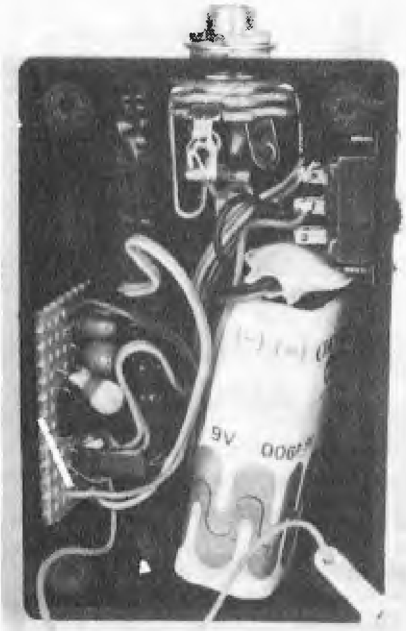
length of six-way cable. This enables a six turn loop to be obtained fairly easily.

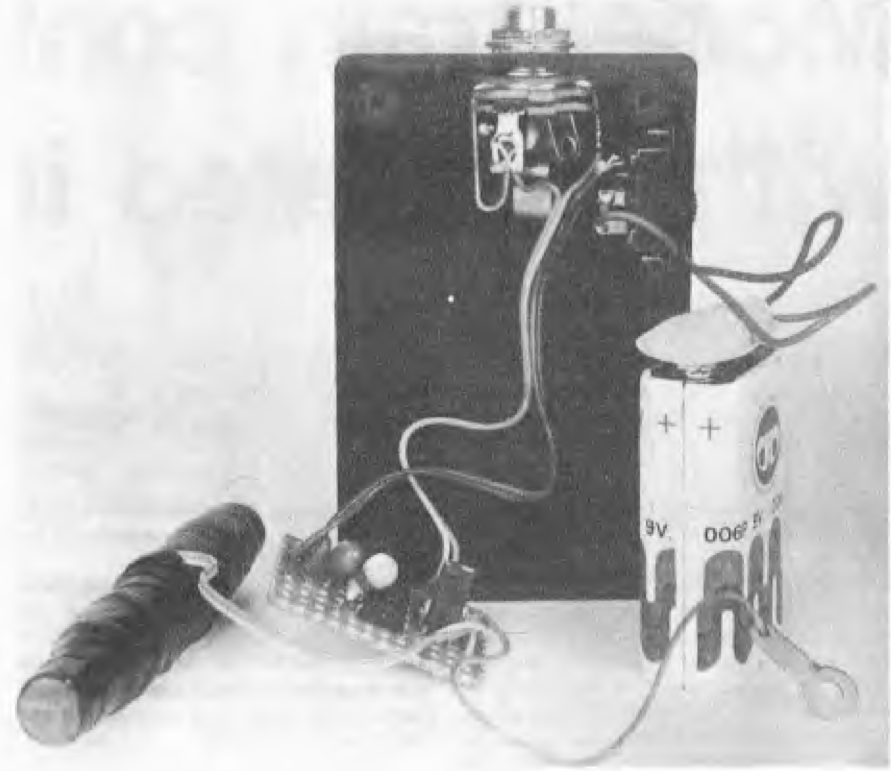
The accompanying photograph shows how we used a small piece of Veroboard to terminate the cable, and to facilitate the connection of the separate wires into a loop. When we had completed the loop wiring, we were pleasantly surprised to discover that the total loop impedance was about 8 ohms. This meant that no series resistor was required to match the loop into the TV receiver loudspeaker voice-coil circuit.

Alternatives to the type of cable we used include rainbow cable or telephone cable. The important parameter to consider when purchasing cable is the effective cost per metre. In other words, 12-way telephone cable at 60 cents/metre has an equivalent cost of 5 cents/metre, as against plain hookup wire at 8 cents/metre.

For permanent installations, the best place for the cable is behind skirting boards, under carpet, or even under the floor-boards. Check the resistance of the completed cable, and if it is less than 8 ohms, add sufficient resistance to bring the total resistance up to this value. Then fit a suitable cord and plug to the free ends of the loop, so that you can plug it into the earphone socket of your TV or radio.

The first step in the construction of the receiver is to cut the ferrite rod to the correct length, if you have not been able to purchase it already cut. Instead of using a new rod, it is possible to use an old aerial rod from a transistor radio. The existing coil may be pressed into service, although you will still require extra turns.





ABOVE and RIGHT: These two photographs show how the various components are fitted into the case.

To cut the rod, use a three cornered file to make a nick round the circumference, and then simply snap it in two. You will find that it will snap where the nick is. The wire can be wound onto the rod by hand, but this is very tedious. A better way is to use an electric or hand drill.

We used a two speed electric drill with a 9.5mm (⅜") chuck, along with a drill speed control. A suitable speed control is described on page 15 of this project book. Clamp the drill to your bench, or in your vyce, and adjust the speed control to a very low speed (with the drill set for low speed as well!).

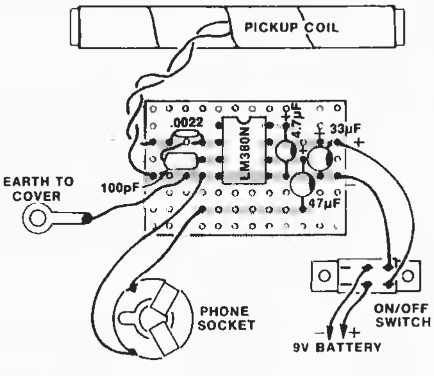
Anchor the start of the winding to the rod with a small piece of insulation tape, and then turn on the drill and commence to feed the wire onto the rod. Use an even tension, and make sure that the turns are wound on evenly, so that the second and subsequent layers will go on easily. When the fifth layer is complete, anchor the end with more tape, and then completely cover the coil with a layer or two of tape.

If you wish, you can solder the coil ends to short pieces of hookup wire, and then tape the joints thoroughly to the rod. This will provide a strong mechanical joint, and prevent the thin winding wire from breaking.

The LM380 is mounted on a small piece of Veroboard, along with the associated capacitors. The circuit diagram shows the connections for the two packages available. The smaller package cannot supply as much output power as the larger one, but is recommended on the grounds of cost, as it supplies ample power for headphones.

Use the photographs as a guide to the placement of the components, as there is not much room in the box. The headphone socket is mounted at one end, with the power switch near it. The rod lays along one side, with the Veroboard assembly lying at an angle over it. The battery is laid along the other side, near the power switch.

The aluminium lid of the box should be connected to the negative side of the battery, as otherwise spurious sounds are produced when it is touched. To test the completed system, simply try using it. With the volume control on the sound source set at a normal listening level, and the loop energised, sound should be heard in the phones whenever the receiver is inside the area of the loop. Note that the ferrite rod in the receiver must be held perpendicular to the plane of the transmitter loop, for maximum pickup.



ABOVE: Use this diagram to aid the placement of components on the Veroboard. A different layout is required for the 14-pin package.

ABOVE: This photograph shows how we terminated the transmitter loop onto a small piece of Veroboard.

The volume of the received sound can be varied by varying the volume of the TV or radio driving the transmitter loop. If required, a volume control can be fitted to the receiver by inserting a 500 ohm potentiometer in series with the phone jack

If it is required to drive the transmitter loop at the same time as the TV speaker, it will be necessary to connect the loop in series with the speaker. To do this will most likely require modifications to the set, and these should only be attempted by those qualified to do so.

Finally, we would like to point out that more than one receiver unit can be used with a single transmitter loop.

Model train control with simulated inertia

This versatile model train unit should prove popular with model enthusiasts. It features simulated inertia, braking and a "kick" circuit to ensure reliable starting. Best of all, it's easy to build.

by DAVID EDWARDS

An ideal model train would reproduce in miniature all the characteristics, problems and perculiarities of the real thing, be it an old coal-burning "Rocket" or a modern diesel-electric ore-train. Unfortunately, such models are unrealisable, and we have to be content with what is available, and more importantly, what we can afford. One area, however, in which improvements can be made is in the field of control.

The simplest method of control is to use a variable resistor in series with the supply voltage. This gives control of the armature current, and hence of the torque. At high speeds this gives quite acceptable control, since the circuit resistance, consisting of the armature resistance and the control resistance, is quite small, and the back emf is the major factor determining the armature current and, hence the torque. This means that the speed of the train is substantially independent of load at high speeds.

Trouble occurs at low speeds, however. The control resistor is set for a large value, so there is a large resistance in the circuit. This means that the supply becomes a constant current supply, and so the back emf is not the major factor in determining the armature current. Hence the speed of the train varies quite markedly with the load, often stalling on gradients and curves.

Probably the most objectionable feature of the simple resistance controller is its poor starting characteristics. It is almost impossible to start a train without it taking off like a rocket, no matter how skilfully the control knob is handled.

To understand why this is so, it is necessary to appreciate the following points:

(a) The torque of the motor is almost directly related to the current through the armature windings.

(b) A very much larger current (torque) is needed to start the motor than is needed to keep it moving.

(c) The simple resistance controller tends to behave as a constant current type power supply: i.e., one in which the current through the armature tends to remain constant in spite of changes in the back emf which the armature generates.

Thus, when we provide enough current to start the train, we are automatically nominating this same value as the running current, due to the constant current characteristic. But this value is far too high for normal running speed, so the current has to be reduced — controller retarded — almost as soon as the train starts to move. Unless done skilfully, correction will either be inadequate or excessive; in the latter case stopping the train unnecessarily. Adding to this difficulty are the effects of friction in the motor bearings and contact problems inherent in transferring power from the rails to the train.

This is where the controller described here scores. It has a constant voltage characteristic, allowing the current to vary according to the motor's requirements, and as dictated by the back emf.

Anyone who has ever compared a real train with a model train would note one glaring difference. A real train, with a small power-to-weight ratio, cannot accelerate or brake rapidly. A model train, with a high power-to-weight ratio, is capable of ridiculous acceleration and braking performances. With some models it is literally possible to stop a train in less than half the length of a carriage. (When this is done, mutters can usually be heard about firemen in fireboxes!)

Of course, inertia can be simulated by being less heavy-handed on the throttle, but this technique is not suitable for automatic signalling systems, where trains have to be started and stopped automatically. What is obviously required is artificial

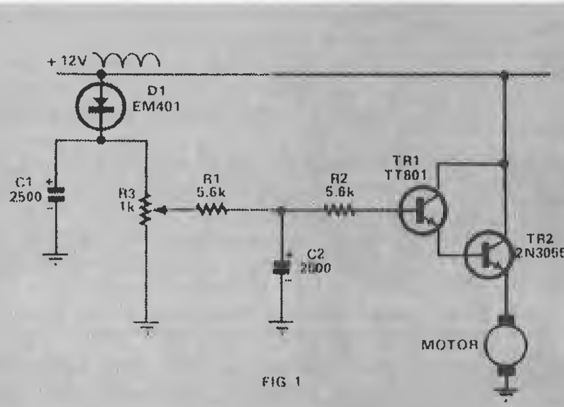


FIG 1

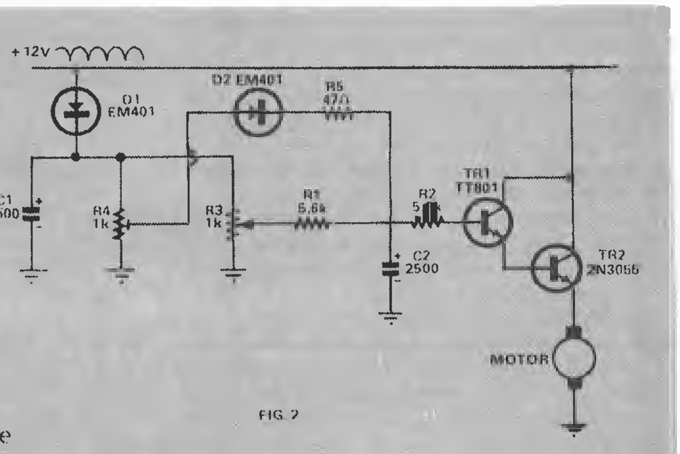
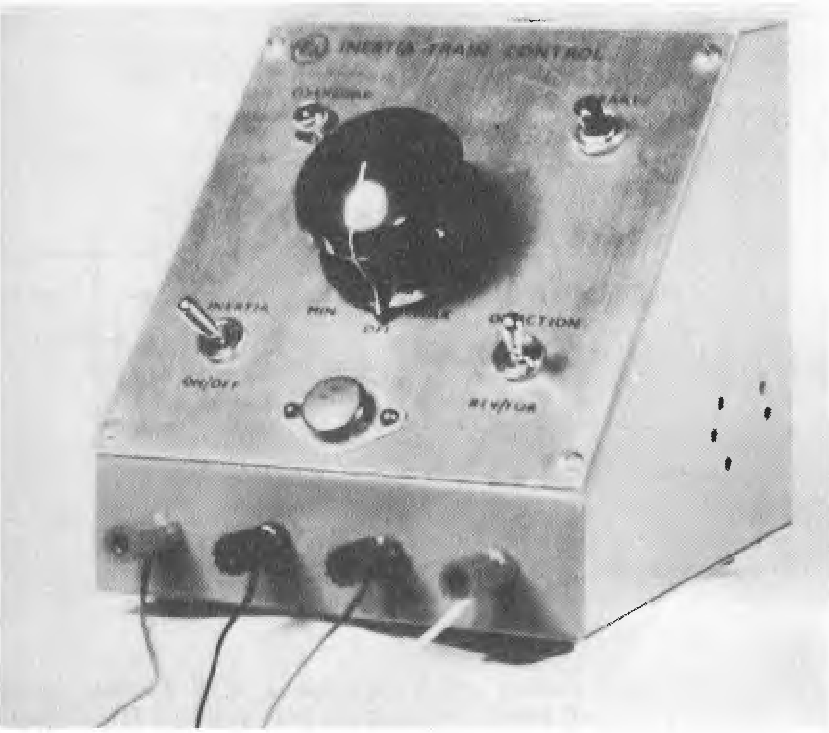


FIG 2

These two simple circuits are quite practical, and may be built as the first step towards our final circuit.



PARTS LIST

SEMICONDUCTORS

4 EM401 silicon diodes, or similar
1 TT801 or BC639 NPN silicon transistor
1 2N3055 NPN silicon power transistor, with insulation mounting kit

SWITCHES

1 2 pole, double throw
1 single pole, to match
1 spring loaded single pole, normally open

CAPACITORS

1 470uf 25VW electrolytic
2 2500uf 25VW electrolytic

RESISTORS (¼W unless specified)

2 47 ohms
1 560 ohms
2 5.6k
1 1k preset pot, linear
1 1k potentiometer with switch (double pole, linear
1 5k preset pot, linear

MISCELLANEOUS

1 panel, see text
1 12V 40/50 watt double filament headlight lamp (see text)
1 12V miniature relay, with two changeover sets
1 knob
1 bezel, red
2 13 bit tag strips

Hookup wire, solder, screws, nuts, 18 gauge tinned copper wire, terminals if required, case if required (see text).

***Note:** resistor wattage ratings and capacitor voltage ratings are those used in our prototype. Components with higher ratings may generally be used provided they are physically compatible. Components with lower ratings may also be used in some cases, providing ratings are not exceeded.*

inertia, and this feature has been incorporated into the design.

The circuit is based on a Darlington pair emitter follower arrangement, to which we have added several features. The main one is the artificial inertia facility, the other features being aimed mainly at getting the maximum benefit from the inertia circuit.

The inertia circuit itself can be switched out if required, since it has been found that precise shunting manoeuvres are sometimes more easily performed without it. The circuit has such good low speed characteristics that the operator can easily provide a realistic performance in these circumstances.

In conjunction with the inertia circuit we have a brake circuit. This provides added realism, in that the train may be allowed to simply coast after power is switched off, or brought to a stop more rapidly by applying the brake. While our circuit uses a simple push button, giving a fixed degree of braking, it would be possible to substitute a pot to give variable braking. Such a pot would have to be spring loaded.

The inertia and braking circuits can be operated from signalling circuits so that a train will reduce speed gradually when appproaching a signal which is against it and stop at the signal until the latter changes. It will then accelerate slowly and eventually resume its normal speed.

Finally, there is what we have dubbed the "kick in the pants" circuit. One of the most annoying situations is that where a train that will not start when a normal starting voltage is applied to the tracks. At best, it will not start until a lot more voltage is applied, at which point it will start with a jerk. At worst it will not start at all, meaning that it has to be pushed with the finger and the whole illusion destroyed.

One obvious cause of this problem is poor contact between the rails and the loco wheels, but there appear to be more subtle causes. To quote just one example; a motor will sometimes start in reverse when it will not start in the forward direction.

Our "kick" circuit is designed to minimise this problem by applying full voltage to the track for a fraction of a second; just enough to get the motor armature moving. The voltage then reverts to that selected by the control knob or the inertia circuit.

In practice the idea works extremely well. The loco starts with a slight jerk — the exact amount can be selected — then picks up speed slowly as dictated by the inertia circuit. The effect is not unrealistic, since the jerk is minimal and normally barely sufficient to take up the slack in the rolling stock couplings.

On the other hand, the starting reliability is very high. Even when a loco fails to start the first time, a second kick — easily applied — will often be effective. In extreme cases the situation can sometimes be salvaged by switching to reverse, applying a kick without follow-up power, then switching to forward and trying again.

A basic circuit is shown in Fig. 1. The first point to note is the filtering network provided by D1 and C1. A filtered supply proved essential for the control circuitry and, since it was not practical, or even desirable, to filter the supply to the rails, we simply filtered what we needed. The diode/capacitor combination is a particularly effective one.

Inertia is provided by C2, in the base circuit of TR1. The two 5.6k resistors (R1 and R2) each side of it perform a number of functions. Collectively they serve as a current limiting resistor for the base of TR1. Seperately, they control the rate of acceleration and deceleration. R1 controls the rate at which C2 can charge to the voltage set by the moving arm of the throttle pot (R3). R2 controls the rate at which C2 can discharge through the base circuit of TR1.

Their total value also has some bearing on the spread of the throttle movement. If the value is too low TR1 and TR2 may saturate before the throttle is fully advanced, making its operation critical, If too high, the power available to the track will be limited. The values chosen are a compromise between all these requirements.

While the amount of inertia could be varied by varying these resistors, this is not recommended in view of the factors just mentioned. The better approach

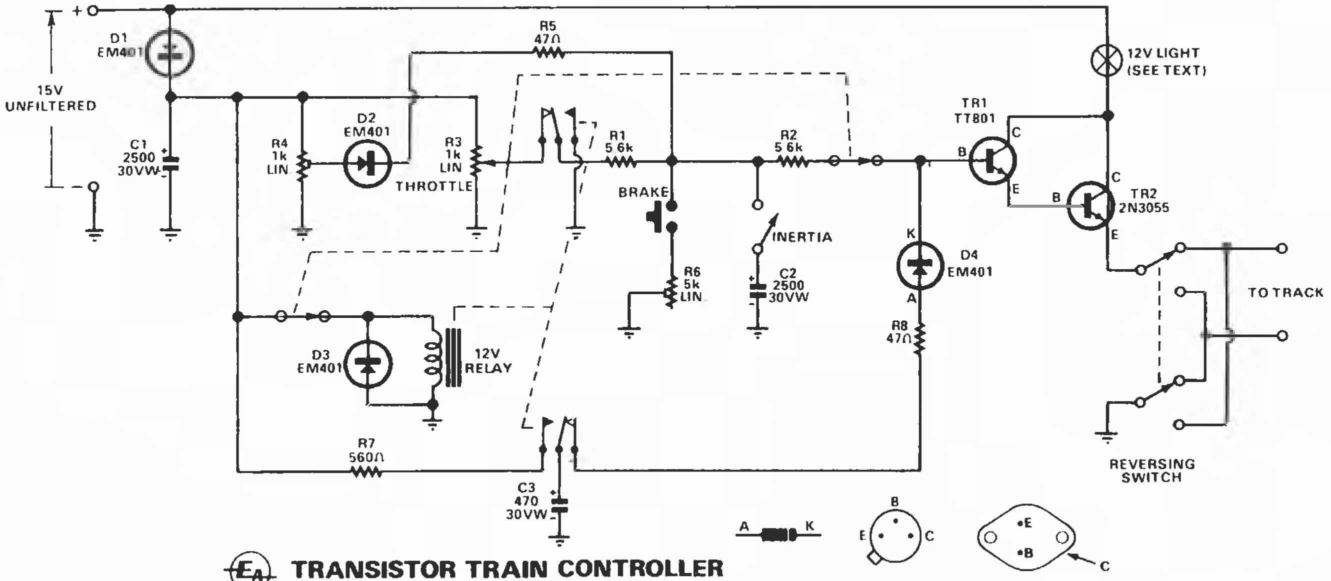


FIG 3

TRANSISTOR TRAIN CONTROLLER WITH INERTIA

would be to vary C2 although, in practice, the value we have chosen should suit most situations. In this regard it must be remembered that the final circuit has a brake function which can override the natural deceleration function.

This simple circuit is quite practical and, in fact, the reader may care to build it to this point as a first step. This approach is particularly recommended for those whose knowledge of electronics is minimal.

However the circuit has several limitations. The most serious is that when the throttle is advanced from zero the train hesitates for a time until the voltage increases to the minimum necessary to start it. To overcome this problem it was decided to prevent the inertia capacitor from discharging completely. This is accomplished by adding a 1k tab pot (R4), a diode (D2), and a 47 ohm resistor (R5), (Fig. 2).

The setting of R4 determines the minimum voltage across C2 and, therefore, the minimum speed of the train. Diode D2 isolates the two circuits so that the voltage determined by R4 is effective only when it is greater than the voltage determined by the throttle (R3). Once the voltage from R3 is greater, the diode is reverse biased and ceases to conduct. R5 is simply a limiting resistor.

In use, R4 can be set so that a train will just stop with the throttle fully retarded, but one setting may not suit all locos, or even the same loco when it is either hot or cold. In practice it is best set for a minimum speed, the brake circuit being used to bring it to a stop.

The only snag with this idea is that when the brake is released the train may start again before it is required to do so. To overcome this we modified the throttle (R3) to a switch pot, the switch being used to open-circuit the base connection of TR1 (Fig. 3). With this arrangement the throttle is first moved to the minimum position until the train slows to a minimum speed, the brake applied to stop it, and the throttle then switched to the "off" position to prevent it starting prematurely.

This switch has another useful function. It will stop the train instantly and is very valuable in the event that a possible crash is likely to damage an expensive model. In these circumstances realism takes second place.

The braking system is shown in the final circuit (Fig. 3). It consists of a 5k tab pot R6) and a push-button switch between the base circuit of TR1 and chassis. When the switch is closed C2 is discharged through R6 and all the voltage removed from the base of TR1, bringing the train to a halt. The circuit overrides the minimum speed circuit involving R4 etc. The rate at which C2 is discharged depends on the value of R6, which can be set by the builder for greatest realism.

Once again, we suggest that readers may care to build the unit to this stage, and test it, before proceeding further, in fact we built our own unit to this stage and experimented with it for some time before evolving the next feature.

This is the "kick in the pants" circuit previously mentioned. The idea was born largly of frustration; the frustration of both ourselves and most other model train enthusiasts when a train refuses to start on cue.

Having been reminded of just how frustrating this can be while testing the new controller we began to wonder whether something could be done about it. At first we tried simply discharging the largest capacitor we could find directly across the rails. While impractical, it did prove that a kick of this kind would start a stalled loco almost as effectively as jabbing it with a finger — and a good deal more realistically.

A more practical approach was to discharge a much smaller capacitor into the base circuit of TR1 at the moment the throttle was advanced from zero. Again, a manually operated mock up proved the worth of the idea.

The problem was how to operate the kick circuit automatically from the throttle. While we had a spare set of contacts on the switch pot, and this seemed a logical place to start, the simple switching action it provided was not adequate. We needed a changeover combination so that the kick capacitor could be switched into a charging mode while the train was stationary, then switched to discharge through the base circuit when the pot switch was operated.

While we considered a number of schemes, including adding extra switch functions to an existing pot shaft, they all presented problems of one kind or another. Finally we took what was really the easy way out, and added a relay with the necessary switch functions.

While it might be possible to devise a more elegant all electronic system, we reasoned that relays were something with which most train enthusiasts were readily familiar and could probably supply from their junkbox. Even if they had to buy one, they would probably be happier with it than a complex circuit which they could not understand.

As it turned out the decision provided a worthwhile bonus. With an extra set of contacts on the relay — normally provided anyway — it becomes relatively simple to use the control unit with a signalling system while retaining the inertia effect. As shown in Fig. 3 the extra set of contacts are connected in the moving arm circuit of R3.

The kick circuit consists of a 470uF capacitor (C3), the relay changeover set, two current limiting resistors (R7, R8) and a diode (D4). When the throttle is set to the off position the relay coil is disconnected by the pot switch and the

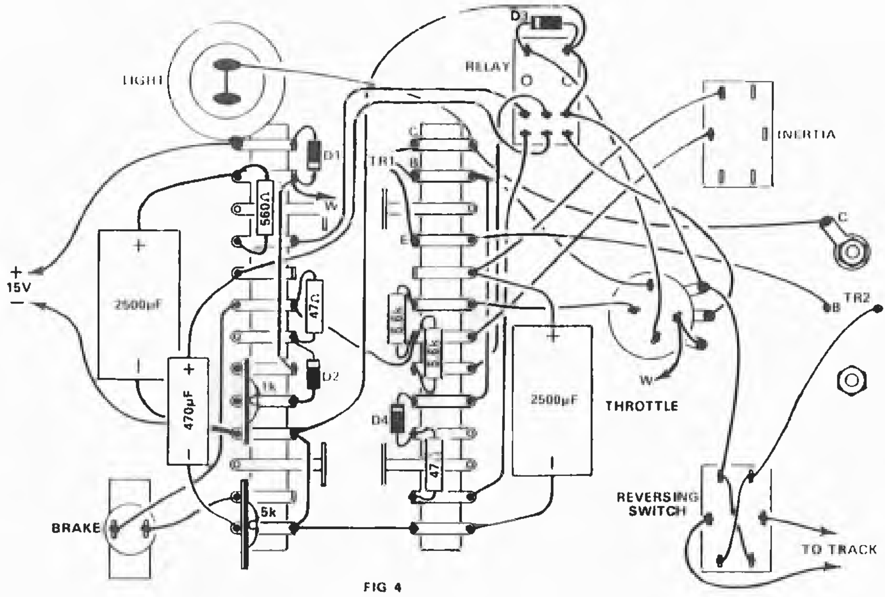


FIG 4

Follow this wiring diagram in conjunction with the circuit and photographs.

relay connects C3) to the filtered supply rail via R7. C3 charges in a fraction of a second and remains charged until the relay is activated by the throttle being advanced.

When this happens, C3 is connected directly to the base circuit of TR1 and, for a very brief period until it discharges, switches TR1 and TR2 into full conduction. As a result, full voltage is applied to the loco for long enough to start the motor moving, but not long enough to produce any significant high speed movement of the train. As C3 discharges, the minimum speed circuit takes over, followed by the inertia circuit.

Overload protection is by a filament lamp, functioning as a non-linear resistor in the collector circuit of the Darlington pair. During normal running conditions, the current in the lamp is a small fraction of its normal rated current, and the lamp resistance and the voltage across it are very low. This means that the voltage being applied to the loco is not measurably reduced.

During overload conditions, such as when the loco is derailed and short circuits the rails, the current through the transistor and the lamp increases. The resistance of the lamp increases by a factor of about eight, so the voltage across it increases to a value close to the normal rated voltage. This limits the voltage across the transistor to a safe value. The light output from the lamp can be used as a visible overload warning by placing it beneath a red bezel.

The wattage rating of the lamp depends on the power consumed by the train. It must be large enough so that under normal running conditions the filament does not heat to any noticeable extent — this can be checked by observing the filament, which should not glow at all. On the other hand, the wattage should not be so high that the maximum permissible ratings of TR2 are exceeded. In practice, with the largest lamp likely to be readily available, these ratings are not even approached.

We fitted a 12V 50/40W twin filament car headlight lamp, with both filaments in parallel. This should be large enough for almost all likely situations, yet provides adequate protection for TR2. The only real objection to this arrangement is the cost of the lamp (about $3), although it should be appreciated that, in this role, it should have an indefinite life.

A possible compromise is to use a discarded lamp in which one filament has been burned out. This may restrict performance slightly for larger locos, or when double heading, but not seriously. The next compromise is a 21/6W stop tail light, with both filaments used to make a 27W lamp. This would be suitable for use only with small locos but, if two such lamps were used in parallel, making a 54W unit, performance will be at least as good as from a single filament headlight lamp. Since these lamps cost only about 45c each they are a much better proposition financially.

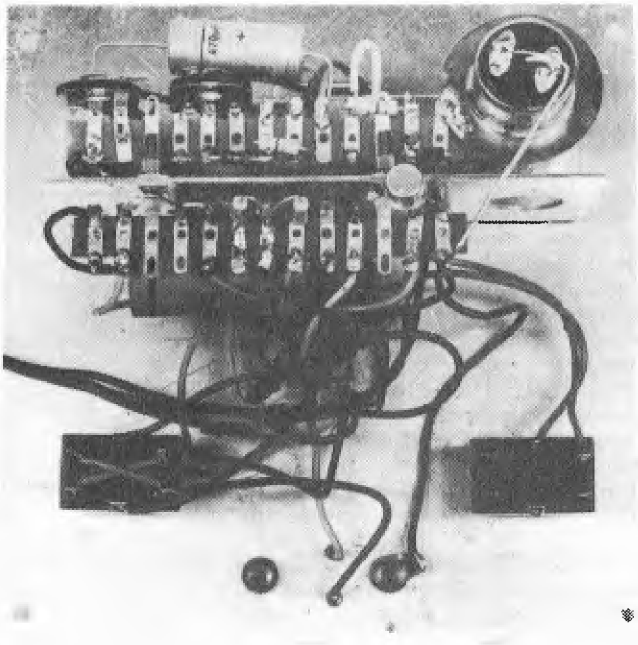
In constructing the unit, we elected to fit all the components onto a single front panel. The idea was that the panel could be fitted easily into an existing control layout, or it could be used as the lid or top panel of an available box. We used the latter idea, and dimensioned the panel to suit a standard sloping panel instrument case (approx 15 x 15 x 15cm). The panel layout is shown in the photograph.

This is a suggested layout only, and constructors may wish to vary it. We found that as the design evolved, there was not enough space to mount all the components, so a right-angle bracket was used. This was attached to the panel by an overload bezel and the brake switch, thereby avoiding unsightly screws on the front panel. To this panel was fixed the relay and the two tag strips.

The wiring and layout of components on the tag strips is not critical. Our layout is shown in Fig 4.The preset pots should be positioned so that they are readily accessible for adjustments. We found it an advantage to use coloured wires, as this makes the wiring easier to trace when it is being checked.

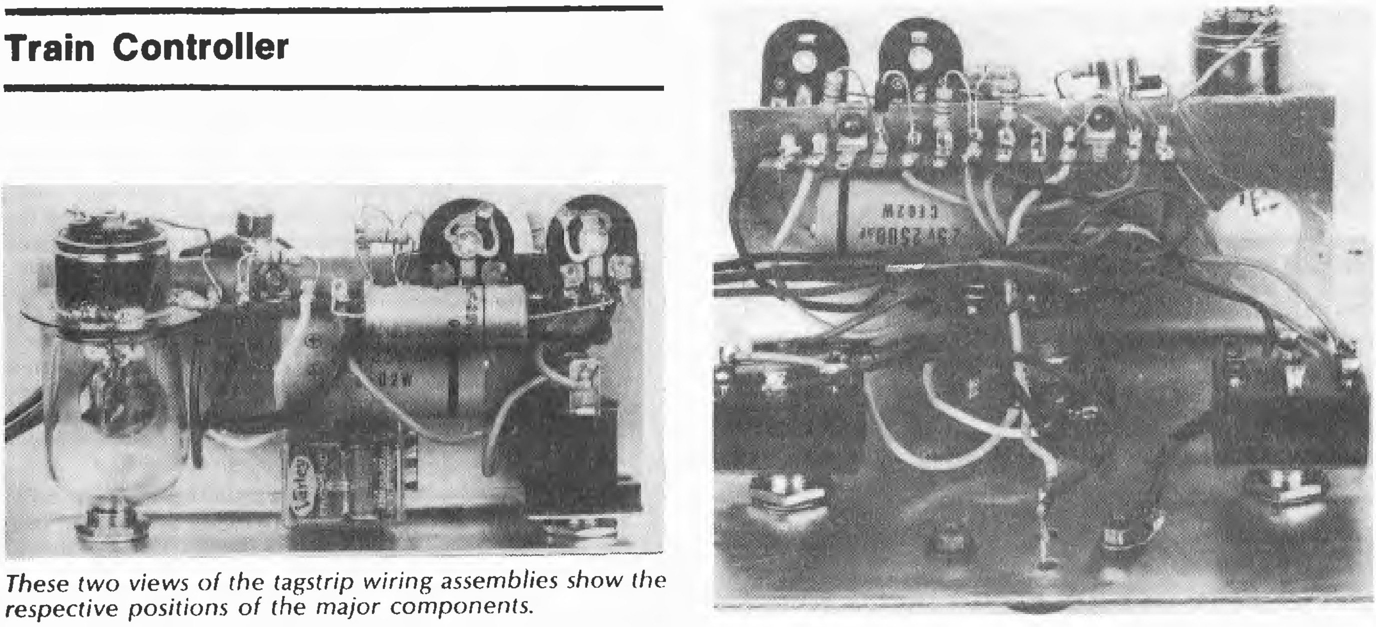
We mounted the light bulb using heavy gauge tinned copper wire, which provides both electrical connection and mechanical support.

When the unit is completed and checked, it can be connected to a suitable supply, being careful to ensure the right polarity. The output can then be connected to a track, preferably a circular one as continuous running facilitates testing, and a train placed on



Most of the components are mounted on two tagstrips attached to an L-shaped bracket. The reversing and inertia switches can be seen at lower left and lower right respectively.

Train Controller


These two views of the tagstrip wiring assemblies show the respective positions of the major components.

the rails. The inertia is switched off, and R3 set to the minimum speed position. (Not the off position.)

The minimum speed is then set by the present pot, R4. It is set so that the train will run steadily at a slow speed, but so that when the train is stopped, say by momentarily touching it with a finger, it will remain stopped.

The "kick in the pants" effect can now be tried, by switching R3 from minimum to off and back again. The train should stop when switched to off, and start with a small jerk when switched to minimum speed. If this jerk is too violent, C3 can be reduced in value. If the train does not start reliably, the value can be increased.

It should now be possible to vary the train smoothly from minimum to maximum by R3. When the train is at full speed, the track can be shorted out. The train should stop, and the overload indication should glow. When the short is removed, the train should move again.

With the train stationary, and the speed control in the off position, the inertia can be switched in. Allow a few seconds for the inertia capacitor to charge to the voltage set by the minimum speed pot, and then advance the speed control to the full speed position. The train should start immediately with a small jerk (due to the "kick in the pants"), and then accelerate slowly to maximum speed, which should be reached in about 15 seconds. When the speed is reduced to the minimum setting, the train should slow to its minimum speed in about the same time. It should not stop.

With the train running at minimum speed, depress the brake. This should stop the train in a short distance. This distance is set by R6 and can be varied to suit individual requirements.

Alternatively, the brake can be adjusted with reference to the distance required to stop from full speed. With the train going at full speed, and the inertia switched in, set the speed control to minimum, and apply the brake. The train should stop in a distance that is realistic in comparison to the distance taken to coast from maximum to minimum speed.

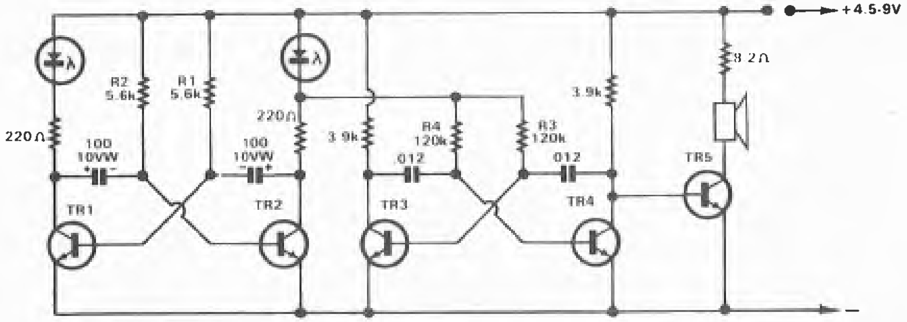
The power supply required to run the train and controller should be capable of supplying a nominal 12V DC, with a current rating of from 2 to 5 amps. Best performance will be obtained if the supply is not smoothed. We used the "Train Power Supply," as described in the April 1968 issue, of "Electronics Australia" set on the 15V tap. The normal commercial "train transformer/rectifier" should be quite suitable, since the majority of these units consist of a 15V transformer and associated rectifier.

It should be remembered that best performance will only be obtained from the controller if the rails are kept clean and free from dirt, to minimise contact resistance. Rail joint resistance is also a cause of poor performance. This can be minimised by connecting the power to the rails at several points.

Hee-haw siren for toys

This hee-haw siren was installed in a toy fire engine in order to provide a more interesting realistic toy. Although many siren circuits have been described, this one has the advantage that a wide variety of transistors may be used, and it also provides one or two flashing beacons.

Transistors TR1 and TR2 form a multivibrator with a period of about 0.6 second, flashing the LED beacons and "frequency modulating" the multivibrator formed by TR3 and TR4. TR5 amplifies the output and drives the speaker.

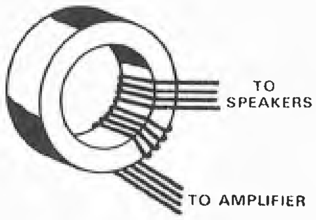


In the unit constructed, the output transducer was a telephone receiver insert, which has the advantage of being rugged and waterproof. A small speaker from a scrapped transistor radio could also be used. If a speaker with an impedance greater than 22 ohms is used, the series resistor may be omitted. If only one beacon is required the LED in the collector circuit of TR1 may be omitted and the 220 ohm resistor increased to 560 ohms.

(By Mr A. Ohsberg, PO Box 178, Nedlands, WA 6009.)

Toroid filter minimises radio, TV breakthrough

The signals from powerful radio broadcast, television and other transmitters frequently penetrate the circuits of audio equipment installed in their immediate vicinity. The simple precautionary measure described in this article may provide a way out of the problem for at least some listeners.



by NEVILLE WILLIAMS

Powerful RF signals may penetrate audio circuits in a number of ways, of which the best known is via the input wiring to high gain preamplifier stages.

Because amplifiers have to be connected to peripheral devices such as record players, tape players, microphones, etc, a metre or more of connecting cable is usually involved and this can act as an antenna to pick up signal from the RF field in the vicinity of a transmitter. The resulting sound may be a distorted murmur, or recognisable program material, or it may be a raspy 50Hz frame buzz from a television picture transmitter.

Precautions against RF penetration into the front end of audio equipment include minimising the length of connecting leads, complete metallic shielding and the use of twin balanced leads right up to the amplifier input, the leads being inside, but isolated from, the outer shielding.

RF which penetrates an amplifier system via the input or early stages can usually be identified because it is subject to normal volume control action.

If the interfering signal is not affected by the volume control, there is a strong possibility that it is penetrating the power output circuitry directly, and the chances of this happening are quite high with modern amplifiers.

There are a number of reasons for this. Firstly, with stereo and quadraphonic equipment, the loudspeaker leads are usually quite long. They are rarely shielded and they can therefore pick up a lot of RF energy.

Modern transistor power amplifiers are notable for their wide passband and their high loop gain around the feedback network. Because of these factors, it is very difficult to limit their response internally to audio only.

RF bypassing across the loudspeaker leads may not be effective because of the very low impedance of the circuitry, besides which added capacitance may have an adverse effect on amplifier stability. Shielded loudspeaker leads could suffer the same criticism, besides being expensive and cumbersome.

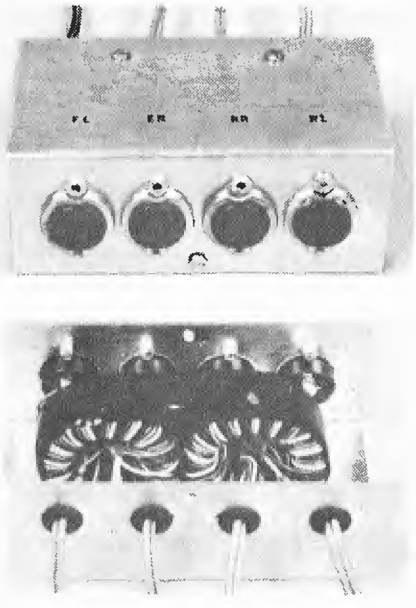
Faced with this situation, the writer resorted to a measure which worked like magic. The persistent background murmur from a nearby broadcast transmitter was reduced to complete silence. A very faint buzzing hum also disappeared, which had obviously been coming from four not-too-distant TV transmitters. As a further and quite unexpected bonus, a switching transient from the refrigerator was also reduced.

There are four loudspeakers in the particular listening room, one pair relatively close to the equipment shelf, the other pair about thirty feet away. The interference problem has centred mainly around the distant pair of loudspeakers and their long connecting leads. Whenever they were connected to a solid-state amplifier, there was a strong chance of getting free background music from the nearby transmitter!

The "magic" cure?

Beg, borrow or buy an ordinary ferrite toroid, typically 3 to 4cm outside diameter. They are scarce enough these days that you probably won't have to pick and choose between types, but don't let that worry you. Use what you can get.

The idea is to wind the loudspeaker leads through it as many times as possible, just before they enter the amplifier, so that they become part of a lumped series inductor.



Filter for a 4-channel amplifier assembled in a small aluminium box.

In our own case, the leads were rather stiff figure-8 flex and we made up a separate prototype filter with plugs and sockets attached so that it could be located just behind the amplifier. It was this plug-in unit that proved the point so effectively.

To make it up, we obtained a suitable toroid and four lengths of thin hook-up wire of different colours and each about 1¼ metres long. We wound the four leads through the toroid, getting on about twenty turns of the four-wire group. Taking care to preserve loudspeaker identity and polarity, we connected one set of ends to the amplifier output circuitry and the opposite ends to the loudspeakers.

The interesting point about such a unit is that the circulating currents for each loudspeaker cancel in the toroid so that the amplifier does not see the toroid as a series inductor. For the same reason, there is no tendency for coupling between the individual loudspeakers.

However, for RF fed into the loudspeaker cables from the transmitter field, the toroid looks like a substantial inductive impedance.

We did not try to take the idea further to see just how many or how few leads would suffice, on what kind of toroid, and in the presence of what kind of signal. For the purpose, about 20 turns per lead through an over-the-counter toroid worked fine and the idea is there for you to work on if you face a different set of circumstances.

Subsequently we made up a unit as pictured, using two toroids in a small folded aluminium box, with sockets attached and plugs on the ends of trailing leads. This is intended as a permanent part of the system.

For this unit, we stripped the four fine colour-coded wires from a length of plastic coated 2-pair telephone cable, which can be bought from some suppliers. With care, it would probably have been possible to wind eight wires for a complete quadraphonic system through the one toroid.

The toroids were wound, insulated separately and then strapped together with adhesive tape, so that they would remain in position in the case. Just to make sure, we pressed a piece of sponge plastic over them before finally assembling the case.

One special word of warning: Whatever wire you use and whatever method you use to put it together, make sure that there is no short-circuit across any one loudspeaker or between loudspeaker wiring. Solid-state amplifiers don't take kindly to a shorted output circuit!

Versatile design counts from 0.1 to 99 seconds

Digital Photo Timer

The new photographic timer described in this article utilises all digital circuitry, and has a red LED display (safe for darkrooms) to show the remaining time. Exposure times can be set between 0.1 seconds and 99 seconds.

by DAVID EDWARDS

The unit described in this article will energise a 240V mains socket for an adjustable predetermined time. It is intended to be used with a photographic enlarger unit, to automatically control the exposure time.

As you can see in the photographs, the unit is mounted in a plastic case, fitted with an aluminium lid or front panel. A 240V chassis mounting socket is mounted on one end of the case, next to where the mains cord enters.

The front panel is dominated by two rotary switches and a display window. The remaining controls are all small toggle or push switches. The rotary switches are used to preset a two-digit down counter to a number between 00 and 99. The counter contents are displayed on the LED readouts.

When the start switch, situated in the top left hand corner, is operated, the counter commences to count down at a rate determined by the range switch. The counter can be made to decrement at 1 second intervals or at 1/10th second intervals.

As soon as the counter starts to decrement, an internal latch is set, and the latch's output used to control a relay, whose contacts apply power to the output socket.

When the counter reaches 00, the latch is reset, the power is removed from the output socket, and the counter is reset to the number set on the rotary switches. If the start button is operated again, a further timed interval will occur.

A focus switch is provided, so that the timer may be bypassed, and the output socket energised continuously. This will enable the enlarger to be correctly set up and focused. The remaining front panel control is a mains switch.

The timed intervals are derived from the frequency of the mains supply, so no calibration or setting up is required. The inherent accuracy of the intervals is dependent only on the stability of the mains frequency, and is much higher than is required for normal photographic work.

The circuitry required to implement the timer is relatively complex, and requires a total of 13 integrated circuits. However these are all readily available CMOS types.

Turning to the circuit diagram, we can discuss the operation of the circuit in detail.

The counter at the heart of the unit is formed by two 4029 devices, connected as decade down-counters. Their BCD outputs are decoded by two 4511 devices, and used to drive the common cathode displays. The display intensity is set by the 220 ohm resistors.

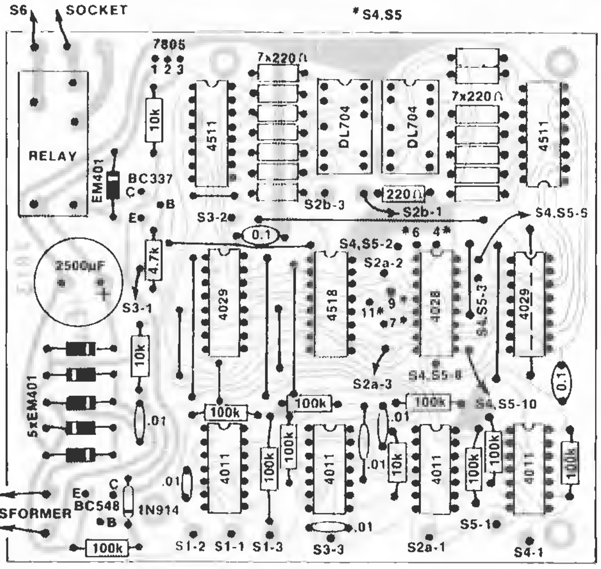
The 4029 devices have parallel loading facilities, and these are used to set the counters to the desired number. The way in which this is done is rather ingenious, however, being a form of multiplexing circuit.

A 100Hz pulsetrain is derived from the output of the bridge rectifier by a BC548 transistor, and used to clock two decade counter-dividers, implemented using a 4518 device. The dividers provide 10Hz and 1Hz signals, which are used to clock the main down counter.

The BCD output of the second counter-divider (IC 5b) is connected to the jam inputs of the 4029s, and also to the input of a 4028 BCD to decimal decoder. Each of the time setting switches (S4 and S5), selects one of the ten decoded outputs.

As the circuit is drawn, the wiper of S5 will go high for 1/10th of a second in every second, and during this time, the BCD code for "4" will be presented to jam inputs of IC 6. Let us accept for the moment that pin 12 of IC 3d is held at the logic 1 state (high).

Pin 13 of IC 3d will go high once every second for 1/50th of a second, during the time that a stable output



The component overlay pattern shows the PC board as viewed from the component side. Note the orientation of the 4511 IC in the top right hand corner of the board.

PARTS LIST

SEMICONDUCTORS
- *4 4011 quad NAND gates*
- *1 4028 BCD to decimal decoder*
- *2 4029 up/down binary/decade presettable counters*
- *2 4511 BCD to seven segment decoders/drivers*
- *1 4518 dual decade counter*
- *2 DL704 common cathode LED displays*
- *1 7805, LM340T-5.0 three terminal regulator*
- *1 BC548 NPN transistor or similar*
- *1 BC337 NPN switching transistor or similar*
- *6 EM401 silicon diodes*
- *1 1N914 silicon diode*

RESISTORS (all ¼W)
- *9 100k, 3 10k, 1 4.7k, 15 220 ohm*

CAPACITORS
- *1 2500uF 16VW PCB mounting electrolytic*
- *2 0.1uF polyester*
- *5 0.01uF polyester*

SWITCHES
- *2 10 position single pole rotary*
- *2 SPDT miniature toggle*
- *1 DPDT miniature toggle*
- *1 SPDT momentary contact miniature pushbutton*

MISCELLANEOUS
- *1 12V 280 ohm SPDT relay with 240VAC rated contacts*
- *1 transformer, 240V to 8.5V at 1A, DSE 2155, A&R 2155 or similar*
- *1 chassis mounting 3 pin 240V socket*
- *1 mains plug, cord, grommet and cord clamp*
- *1 3 way terminal block*
- *2 knobs*
- *1 plastic case, 196 x 113 x 60mm*
- *1 printed circuit board, coded 78t3, 101 x 113mm*
- *2 14 pin DIL wire wrap sockets*
- *1 piece of red Polaroid film, 80mm x 20mm*
- *Machine screws and nuts, tapped spacers, solder, hookup wire, rainbow cable, insulation tape, scrap aluminium, PCB pins*

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with higher ratings may generally be used provided they are physically compatible.

from the 4028 is present. This signal is coupled through gates 3d and 3c, and is combined with the signal selected by S5 in gates 4b and 4a.

Thus the parallel enable input (pin 1) of IC 6 is driven high for a short period while a stable BCD code of "4" is present at the jam inputs, so that the counter is loaded with "4".

In a similar fashion, as the circuit is drawn, IC 7 will be loaded with "6". If the switch positions are altered, the new input will be loaded into the counter within one second. This multiplexing scheme allows low cost 1-pole 10-position switches to be used.

We can now turn to the remainder of the circuit, and see how the timed interval is commenced and finished. Gates 1a and 1b are connected as an R-S flipflop, as are gates 1d and 1c, and gates 2a and 2b.

Flipflop 1 is used to debounce the start switch, S1. The output of this flipflop is differentiated, and used to set the second flipflop. This is necessary so that once the timed interval has commenced, the start switch has no further effects.

The normally low output of flipflop 2, which goes high when the start switch is operated, turns on gate 3b, and allows clock pulses, selected by S2a, to reach the 4029 counters. The first positive clock edge appearing at the output of gate 3b clocks the counters, and also sets flipflop 3, via gate 3a.

This last flip flop controls the output relay, via gate 2d and the BC337 transistor. Flipflops 2 and 3 remain set while the counter counts down. In order to prevent the parallel load circuits from operating, the output of flipflop 2 is used to turn off gate 3d, thus preventing loading pulses from reaching the parallel enable inputs of the 4029s.

The counter counts down till 00 is reached. At this time, the carry out pin of IC 6 goes low, signifying the end of the count. Since one more count is required to obtain the exposure time set on the switches, the trailing edge of this pulse is used to clear flipflops 2 and 3. The integrator before gate 2c is required to remove a small glitch which could otherwise cause false retriggering.

Thus flipflop 3 remains set for the duration of the number of clock pulses specified by the rotary switches, and hence the enlarger lamp remains set for the same period. There is a small delay after the start switch is operated before the lamp is energised, while the circuit waits for the first clock edge to arrive.

The second pole of the range switch is used to energise the decimal point in the most significant display when a 10Hz clock rate is selected, so that the display reads in seconds and tenths of seconds. The focus switch (S3), supplies base current to the relay transistor instead of gate 2d, and thus keeps the relay energised irrespective of the state of flipflop 3.

Construction of this project should only be attempted by experienced constructors, as some fine solderwork is required. All of the components are contained on a single printed circuit board, coded 78t3, and measuring 101 x 113mm. Twelve links are required, one of which runs under IC 7.

Fit all the passive components first, making sure to orientate the electrolytic capacitor correctly. The two wire-wrap sockets are used as spacers to mount the displays off the board. Cut about 4mm off those leads which do not pass through the board, and use them to help position the socket off the board.

Use PCB pins to make all external connections to the board, as they are easier to use, and facilitate later repairs (hopefully not required!). Do not insert the CMOS ICs until all static proof devices, such as the diodes, displays and regulator have been fitted.

Earth the barrel of your soldering iron to the board, and then insert the first CMOS IC. Solder the power supply pins first, and then the remaining pins. Pin 7 or 8 is the earth pin, and pin 14 or 16 is the positive supply line.

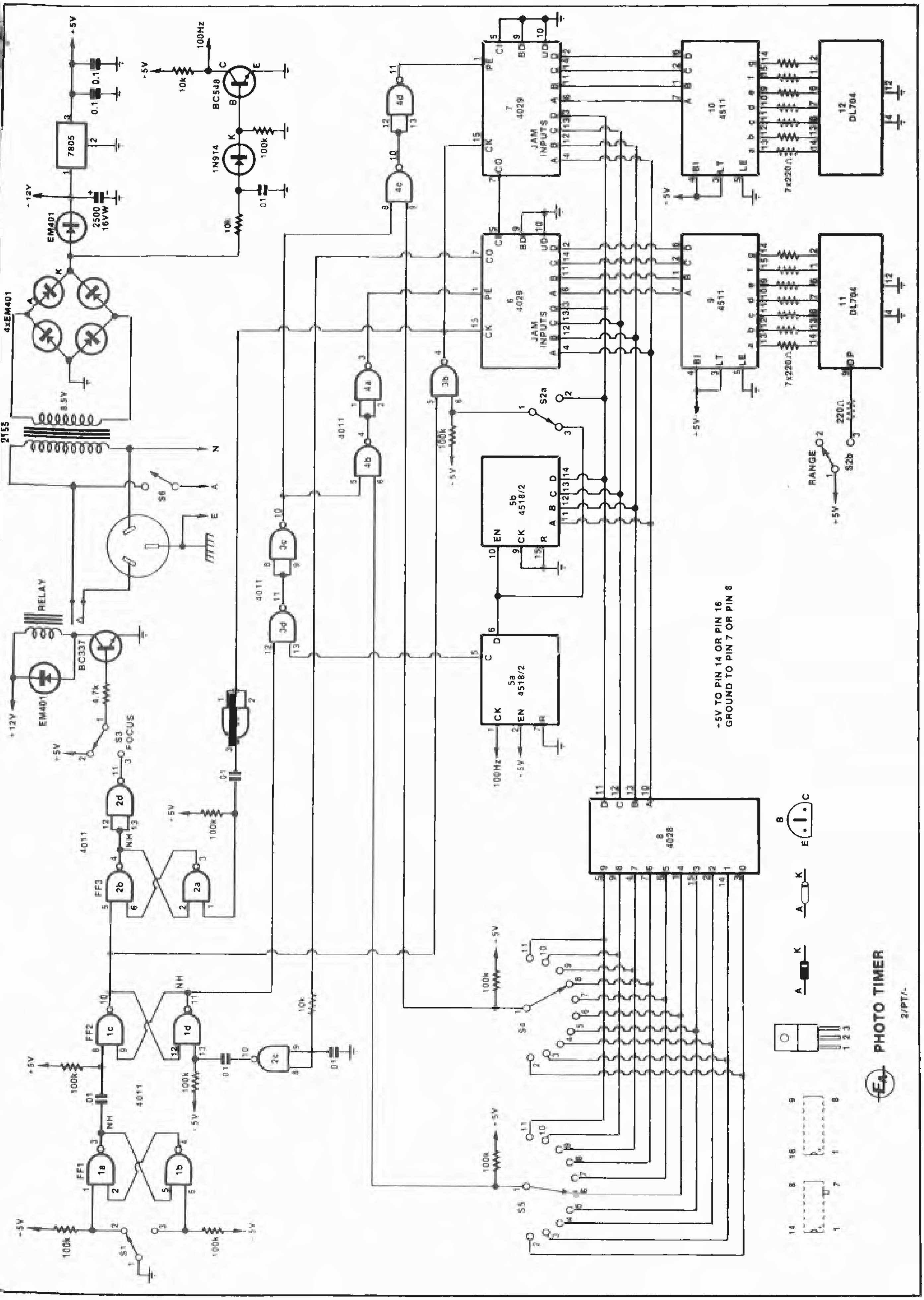


PHOTO TIMER

2/PT/-

+5V TO PIN 14 OR PIN 16
GROUND TO PIN 7 OR PIN 8

Once the PCB is completed, put it to one side, and commence to fit the hardware into the case. The general arrangement we used can be seen in the photographs, and is recommended. The mains cord enters through a grommetted hole, and is clamped to the bottom of the case. The earth lead is securely connected to the transformer frame, and to the metal front panel.

A three-way terminal block is used to terminate the active and neutral connector wires, and the wires from the mains switch. This latter component should be well wrapped with insulation tape, to minimise shock hazards.

The PCB is mounted on standoffs, so that it is as close to the front panel as possible. The height of the electolytic capacitor will be the limiting factor. The connections to the various switches are best made with rainbow cable. We separated the individual wires, and then bound the finished wiring into two cables, as this gave a neater result.

One cable contained the twelve wires from the two rotary switches, while the other cable contained the wires to the other switches. Keep the finished cables well away from the mains leads and components.

The regulator is bolted to the side of the case, with a small piece of scrap aluminium used as a heatsink. Make sure that this is kept well away from the mains connections to the PCB.

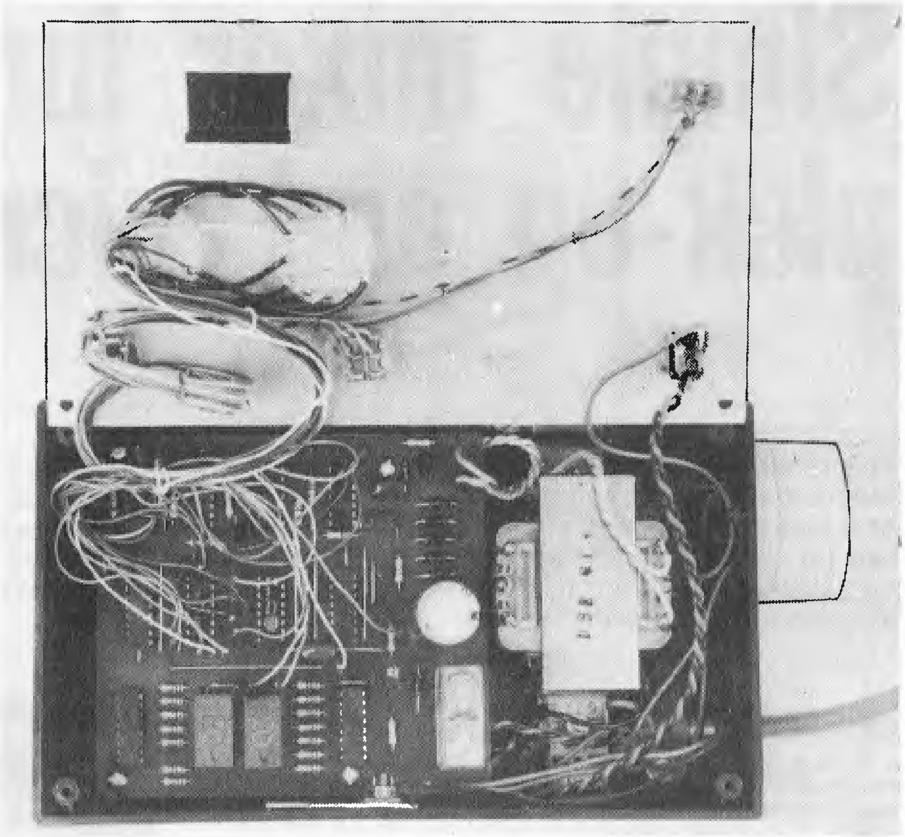
We recommend that the connections to the relay be left off the board, while it is tested. You will be able to see and hear the relay operate, and this will indicate correct operation. On first switch on, the relay may energise momentarily. If this is not desired, break the track leading to pin 12 of IC 2. Connect a 470k resistor from this pin to pin 14, and a 10uF tantalum capacitor between pin 12 and pin 7. Connect the possitive lead to pin 12.

Check the operation of all switches, and that the relay operates for the duration indicated on the display. If you set the display to 00, the relay should not operate at all. Check that the numbers displayed increase as you rotate the switches clockwise.

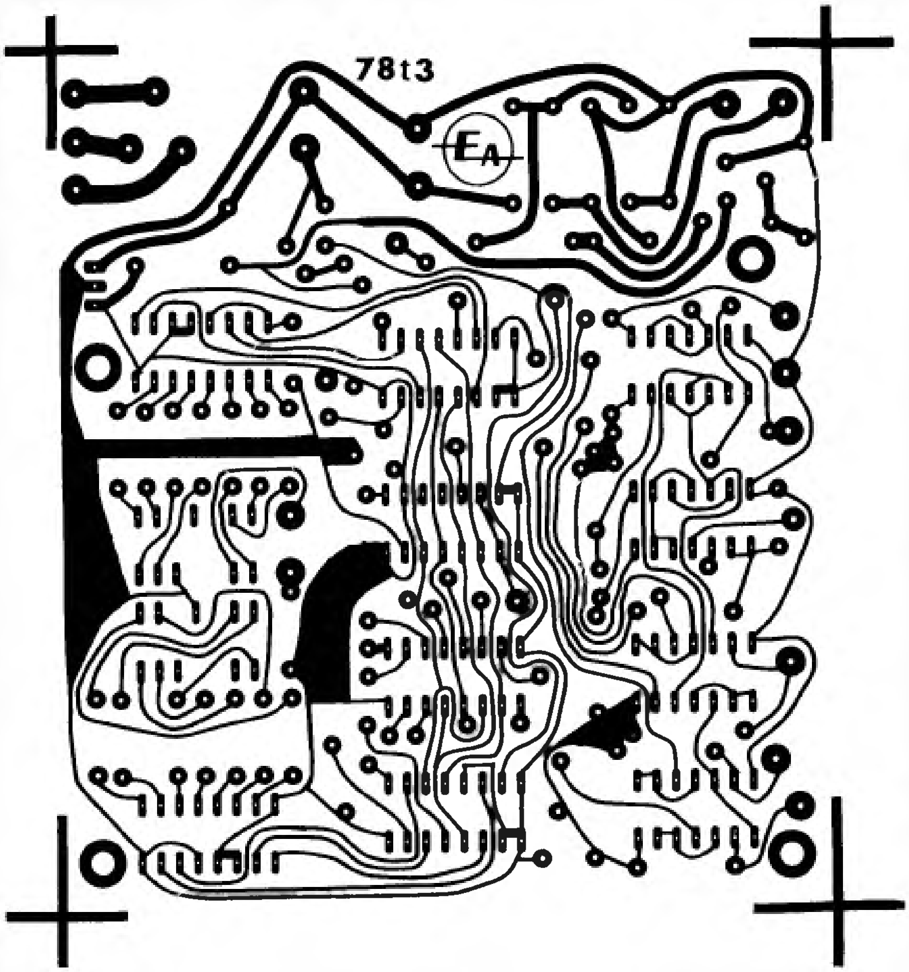
Any faults will most likely be due to construction faults, and in particular to faulty solder connections, or bridges across the tracks. If you encounter difficulties, use a logic probe or similar tool to trace through the circuit.

Once satisfied that all is correct, complete the connections to the relay, and try the unit with a lamp. The bezel for the display can be attached to the front panel with a suitable adhesive, or with double sided sticky tape, while the switches can be labelled with pressure sensitive lettering, protected with a coating of clear lacquer.

The maximum load which can be switched will depend on the relay contacts, which should not be over-rated. Typical relays which will suit the PCB are rated at about 1000W.



Above is a view inside the completed Photo Timer. Note the earth lead run to the metal front panel next to the mains on/off switch. Below is an actual size reproduction of the PC board.



Simple mixer for pick-up and microphone

The little mixer unit described in this article will enable you to mix together a high level source such as the ouput from a record player or a tape recorder, and a low level source such as a microphone. It can be very handy for generating home movie soundtracks and can also be used as a microphone preamplifier for use with hi-fi amplifiers lacking such facilities.

by DAVID EDWARDS

The incentive for this project arose out of a need to mix a microphone with a high level source, to generate the soundtrack for a home movie. But it soon became obvious that a simple mixer capable of meeting these requirements could also be used in a variety of other situations.

For instance, the unit could be used to mix a microphone signal with a high level audio signal, making it possible to "sing along" with records or tapes. Other uses which come to mind include adding an identification (verbally) to computer programs or RTTY messages stored on cassettes, and in adding personal comments to your own recordings.

As you can see from the photographs, the mixer is constructed in a small low-cost metal case. The one used for the prototype measures 150 x 100 x 60mm, and has an aluminium chassis with a steel lid. It was kindly supplied by Dick Smith Electronics Pty Ltd. We elected to power the unit with a battery, both on the grounds of cost and to minimise any possible hum problems.

Readers are referred to the accompanying table for a list of the pertinent specifications of the prototype.

Turning now to the circuit diagram, we can discuss the operation of the circuit. The microphone preamplifier is implemented with a two stage DC coupled pair. DC feedback from the emitter of the second transistor is used to bias the input transistor, while the gain is set by the ratio of the 100k feedback resistor and the effective AC impedance in the emitter of the input transistor.

The collector load of the input transistor is decoupled by a 22uF bypass capacitor, while a 1k/47pF low-pass filter is used at the input to eliminate possible RF interference.

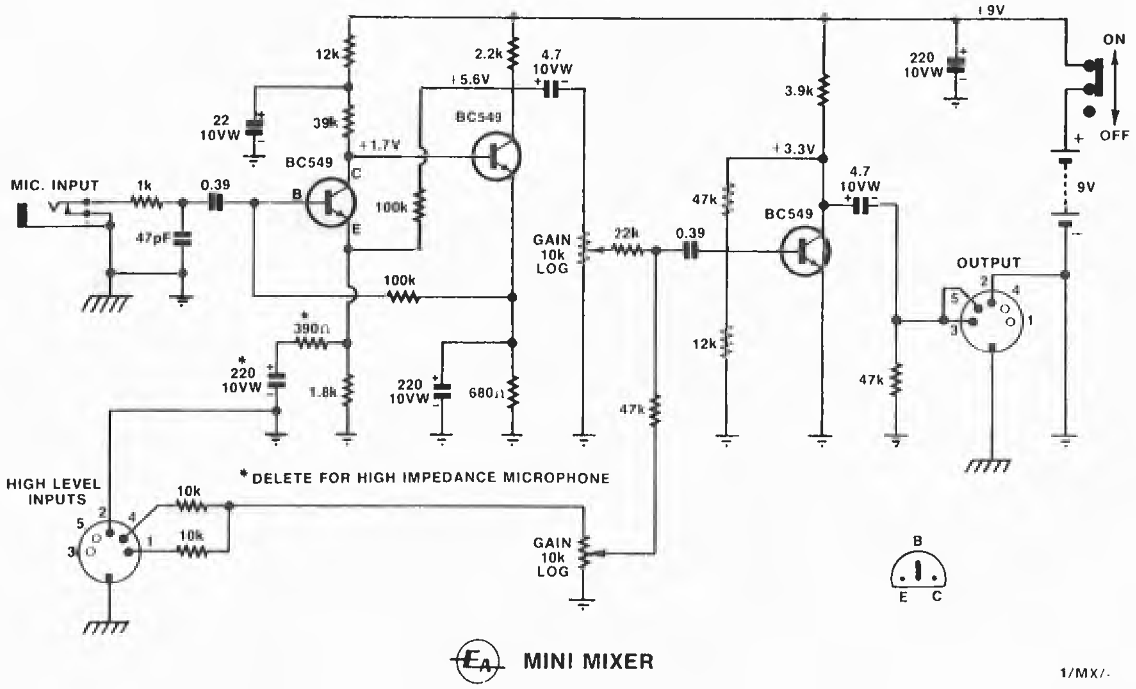
For use with high impedance microphones, the marked components are deleted. This gives a nominal gain of 56. For use with low impedance microphones, higher gain is required, and this is achieved by reducing the AC feedback with the marked components. This gives a nominal gain of 250.

The transistors we have specified have the required gain and noise performance to achieve very close to the nominal gains. Only electrically equivalent types such as BC109s, should be used as substitutes.

A shorting type of input connector has been used for the microphone connector, in order to minimise the input noise when no microphone is connected. We used one of the 3.5mm dia. jack sockets, as this suits the majority of currently available microphones supplied with movie cameras, projectors and cassette recorders.

The microphone preamplifier is intended to work with dynamic microphones of either the low or high impedance type, as were commonly supplied with the cheaper cassette recorders before the introduction of electret microphones. It will also work well with separate electret microphones having an output impedance of around 2k ohms.

No amplification is provided for the high level inputs. Provision is made for



Our circuit is suitable for both high impedance and low impedance microphones.

stereo inputs, which are mixed together passively by 10k mixing resistors. The high level inputs are connected to the circuit via a 5 pin DIN socket, wired so that the mixer unit will be electrically equivalent to a tape recorder, so that it may be connected to an amplifier via a standard DIN cord.

Two 10k logarithmic potentiometers are used to control the levels of the two inputs. The outputs from these controls are mixed in a simple virtual earth mixer. The gain of each channel can be varied by changing the input resistor. We do not recommend that the 22k resistor used for the microphone channel be changed, although in some cases it may be advantageous to lower the 47k high level resistor to 22k in order to increase the gain in this channel.

For the prototype, we provided a separate DIN socket for the output, as this suited the purposes we had in mind. However, for use with hi-fi amplifiers the output could be connected to pins 3 and 5 of the input socket, so that only one cord would be required to connect to the amplifier.

Connection to the amplifier would then be via the tape recorder sockets, and the mixer unit would be switched into circuit using the tape monitor switch.

A miniature slide switch was used for the power switch, with a 220uF electrolytic capacitor in parallel with the battery to ensure a low supply impedance. The DC voltages noted on the circuit were measured with a high impedance voltmeter, with a supply voltage of 9V. They should be taken as representative values only.

A battery voltage of 7V was taken as the design point for the DC bias calculations, so that reasonable performance would be obtained over a wide range of battery voltages. Testing of the prototype confirmed that performance was essentially constant from 6 to 9V.

Construction of the unit should be very simple, as all components are contained on a single printed circuit board, coded 77mx11. This measures 96 x 87mm, and is supported in the case by the connections to the pots and the on/off switch.

Commence construction by fitting the input and output connectors, and the controls to the box. Use the PCB as a guide to position the latter components, remembering to leave a clearance at the top of the box for the connectors. Fit the controls to the box, and then solder short lengths of tinned copper wire to their connecting lugs, and put the assembly aside for the moment.

Now fit all the components to the PCB. Ensure that the polarity conscious components, such as capacitors and transistors are fitted correctly. Use PCB pins to make the connections to the board for the battery lead and the input

SPECIFICATIONS

POWER REQUIREMENTS
9V at 3mA (Eveready No. 216 or similar battery)
Estimated battery life: in excess of 150 hours

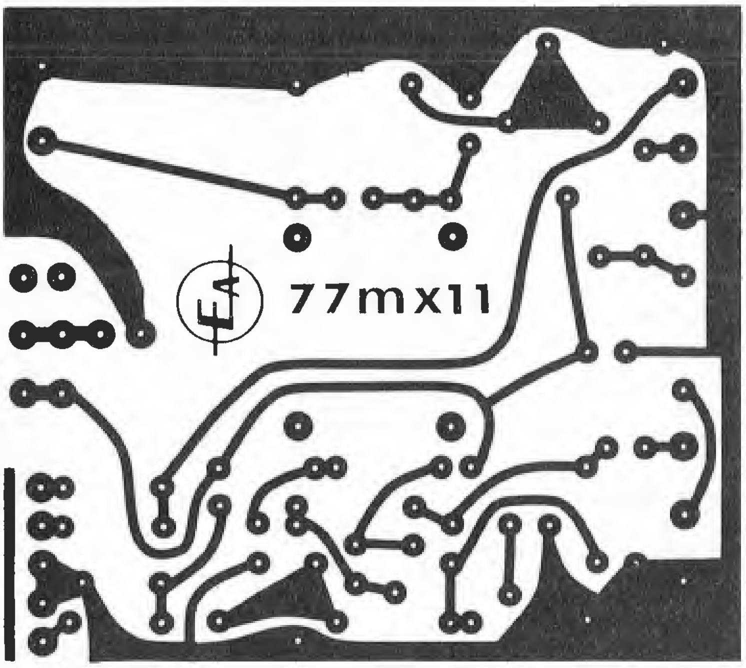
OUTPUT CHARACTERISTICS
Nominal output voltage: 100mV RMS
Maximum output voltage: 2V RMS
Frequency response: 20Hz to 200kHz at -1dB points
Nominal ouput load: 10k ohms or greater

LOW IMPEDANCE MICROPHONE INPUT
Input impedance: 100k ohms
Sensitivity: 0.2mV for nominal output
Input overload: 6mV at 1kHz
Signal to noise ratio: -36dB below nominal output and with S/C input
Distortion: masked by residual noise but less than 0.4% at 1kHz

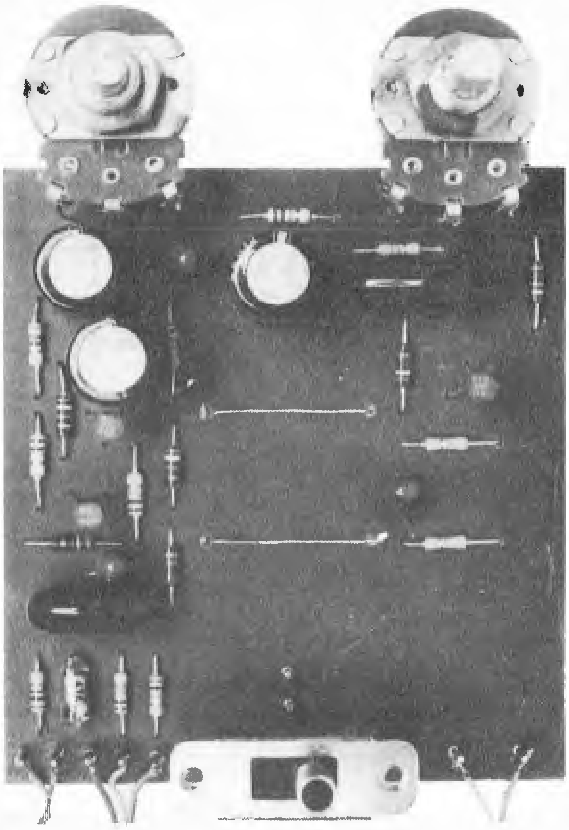
ALTERNATIVE HIGH IMPEDANCE MICROPHONE INPUT
Input impedance: 100k ohms
Sensitivity: 1mV for nominal output
Input overload: 40mV at 1kHz
Signal to noise ratio: -40dB below nominal output and with S/C input
Distortion: masked by residual noise but less than 0.1% at 1kHz

HIGH LEVEL INPUT
Input impedance: 15k ohms
Sensitivity: 250mV for rated output
Input overload: 5V at 1kHz
Signal to noise ratio: -45dB below nominal output and with S/C input
Distortion: less than 0.04% at 1kHz

Mixer for pick-up and microphone



Actual size reproduction of the PC pattern.



Top: the assembled board. Below: the component overlay.

PARTS LIST

- 3 BC549 or equivalent low noise/high gain NPN silicon transistors
- 1 printed circuit board, coded 77mx11, 96 x 87mm
- 1 metal case, 150 x 100 x 60mm, see text
- 2 10k logarithmic potentiometers
- 2 knobs to suit
- 1 miniature slide switch
- 2 5-pin 180 degree DIN sockets
- 1 miniature earphone socket
- 1 216 type 9V battery and clip to suit

CAPACITORS

- 3 220uF 10VW electrolytics
- 1 22uF 10VW electrolytic
- 2 4.7uF 10VW electrolytics
- 2 0.39uF polyester
- 1 47pF ceramic or polystyrene

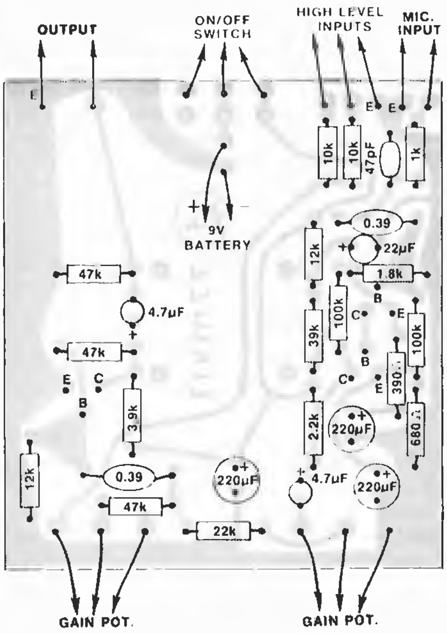
RESISTORS (all ¼W)

- 2 100k, 3 47k, 1 39k, 1 22k, 2 12k, 2 10k, 1 3.9k, 1 2.2k, 1 1.8k, 1 1k, 1 680 ohm, 1 390 ohm

MISCELLANEOUS

Solder, tinned copper wire, hookup wire, machine screws and nuts, cardboard or insulating tape.

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with higher ratings may generally be used provided they are physically compatible.



and output connections.

The battery is mounted on the copper side of the board, but remember to insulate the tracks underneath it with a piece of cardboard or insulating tape. Fix the battery to the board using string or tinned copper wire, using the four holes provided. At this stage, do not connect the battery clip to the battery.

Ordinary hookup wire can be used for the input and output connectors, provided the leads are kept short, and the input and output leads separated. This is facilitated by the pattern on the board. Once all these leads have been fitted, offer the PCB up to the controls, feeding the tinned copper wire through the appropriate holes.

After checking that the board is positioned correctly, solder all the connections, and clip off the excess wire lengths. If at a later stage it is required to obtain access to the top of the board, this can be achieved by removing the controls from the top of the case.

Testing of the unit consists of trying it out, giving all controls, inputs and switches a quick operational test. If the unit fails to operate correctly, check the DC voltages marked on the circuit diagram, and try to isolate the faulty section. Then check for incorrectly soldered joints, wrong components, or faulty components.

In conclusion, the only point to watch is that you remember to turn the unit off when it is not in use, in order to prolong the battery life. Provided you keep this in mind, you should be able to look forward to many hours of happy mixing.

Multi-Band Vertical Aerial

If you are a keen short-wave listener, but lack the space to errect one of the more elaborate aerial systems, this design might well be the answer. Simple to make, it requires very little space, and will give a good account of itself right across the band.

by IAN POGSON

Aerials for short-wave use are many and varied. The variations are generally dictated by a number of factors, some of which are the frequency of operation, cost simplicity or otherwise of construction, ease of erection, directivity required, amount of real estate available, and so on.

One suggestion that has been made from time to time is that, where space is limited, it may be possible to erect a ground plane aerial which, while limited in size, may still offer a reasonable compromise in terms of performance. By reason of the limited size which is practical for such an aerial, it would tend to favour the high frequency end of the short-wave band. Even so, performance may still be acceptable at the lower frequencies.

A ground plane aerial is simple to make, has a low angle of acceptance, and is omnidirectional although this latter point may be a mixed blessing. While it does not predudice reception from any direction, it equally does not allow a particular direction to be favoured — a facility which can be valuable at times. Another point not in its favour is that vertical aerials have a reputation for picking up somewhat more noise than horizontal ones. Even so, we felt that the idea was worth trying.

Initially, we roughed up a simple unit, similar to the basic ground plane as shown in the sketch. Each of the four radials and the vertical sections were made of 2.54 cm diameter duralumin tubing, 4.1 metres long. Details of the actual construction will be given later.

With the four radials actually on the ground, we connected a coaxial cable with the braid to the radials and the inner conductor to the vertical element. The cable, about 15 metres long, was connected to a full coverage receiver. The aerial in this form resonated at about 16MHz.

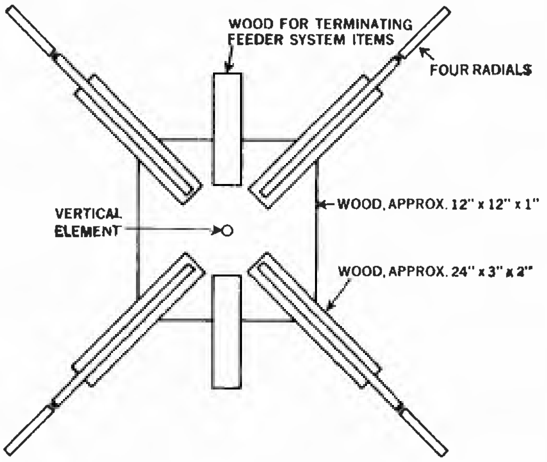
A listening test was very encouraging. Strong signals were received over a wide range of frequencies. These included international broadcast stations on frequencies between about 7MHz and 21MHz, together with amateur signals on three bands included in this frequency range. On 14MHz in particular, amateur signals were excellent from interstate as well as overseas, including British and European.

Listening over a couple of weeks showed that this aerial would be ideal for many short-wave listeners. Naturally the performance would be best around the resonant frequency of 16MHz but results showed that it is quite satisfactory over at least the frequency range originally quoted and if some fall off in response can be tolerated, it can be used right down to the broadcast band.

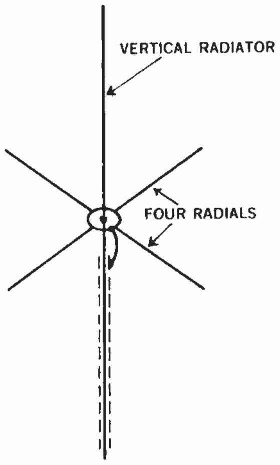
Our construction was based on a "chassis" consisting primarily of a piece of board about 30cm square and 2.54cm thick. Four pieces of 7.6 x 2.54cm about 60cm long were added to the board, as shown in the sketch. These are to provide a fixing for each of the radials, the radials being held in place with two saddles for each. In addition to the four pieces of 7.6 x 2.54cm just mentioned, we added an extra two pieces as shown, about 30cm long. These are optional but handy to accomodate stand-offs, terminations, etc, for the feeder system.

Fixing the vertical element can pose some problems. We screwed a stand-off ceramic insulator to the centre of the board, the diameter of the insulator being such that it was an easy fit inside the end of the tubing. The vertical element was then stabilised by using four guys, one to each of the radials. We used standard galvanised wire for the guys, broken by egg insulators about 60cm apart. A point about 1.2 metres up the vertical and about the same distance along the radials from the centre would be satisfactory. In the construction, we made use of clamps intended for TV aerial use.

Even with the aerial about 30cm above ground, it is remarkable just how well it performed at the writer's location. Although it was difficult to judge performance at this level, compared with the aerial raised to 8 metres above ground, there did not seem to be a great deal in it, at least on listening tests. Even with the radials at 15 metres above ground, little difference could be detected. In short, it would seem that the low angle of acceptance for which the ground plane is reputed, is virtually unchanged by height above actual ground.


WOOD FOR TERMINATING FEEDER SYSTEM ITEMS
FOUR RADIALS
VERTICAL ELEMENT
WOOD, APPROX. 12" x 12" x 1"
WOOD, APPROX. 24" x 3" x 2"

The layout of the base constructed by the author to support the vertical element and the four radials for the aerial system covering the 14, 21 and 28MHz bands.



A basic ground plane aerial. It can be mounted as high as practical above the ground.

For Saturday-afternoon mechanics here is a

Tacho for tune-ups

There must be many Saturday-afternoon mechanics who wish they had access to a tachometer to enable them to correctly adjust the carburettor and ignition system. Here then is a tachometer for just this purpose. It is suitable for both CDI and conventional ignition systems.

by LEO SIMPSON

Years ago, it was considered an easy task to set the idling speed and mixture of the average motor car. You just set the idling speed so that the motor ran reasonably smoothly without "missing a beat", and then adjusted the mixture so that the motor ran smoothly with no tendency to cut out when the accelerator was suddenly closed and gave good response when the accelerator was suddenly opened. Perhaps you then readjusted the idling speed screw to revert to the desired idling speed and that was that. More or less. It did not really matter. Petrol was less expensive and engines were less critical.

No longer is the task simple. And on cars made in 1974 or after, the idling mixture screw is sealed to prevent adjustment by the home mechanic. Only the idling speed can be adjusted and for this task a tachometer of known accuracy is essential. This is particularly the case for cars with automatic transmission.

For example, the idling speed of a typical 6-cylinder car with automatic transmission is in the region of 500 rpm. If the setting is too high, the car tends to leap forward as soon as your foot is removed from the brake and if it is too low the engine will run roughly, have a tendency to stall and have higher than usual bearing wear.

Ignition timing adjustments also require the use of a tachometer. For example, the initial ignition timing advance on a Holden HQ 6-cylinder model is 5 degrees BTDC (before top dead centre) at 480 to 520 rpm. This engine speed is obtained with the transmission in Drive (with the handbrake hard on) and the vacuum line to the distributor diaphram disconnected and plugged.

Operation of the centrifugal advance mechanism should be checked by running the engine up to about 2000 rpm (in neutral).

So a simple bench tachometer is a very useful aid to the home mechanic. Accordingly, we have produced the simple instrument presented here. It has two ranges: 0 to 1000 rpm and 0 to 5000 rpm. The low range is suitable for idling speed adjustments on most cars while the higher range will enable tests at higher speeds.

The higher range is optional. Although marked 0-5000 rpm, this by no means implies that you should run any engine up to 5000 rpm while in neutral. In fact this is likely to put a piston through the head. And that is a repair job outside the scope of the home mechanic.

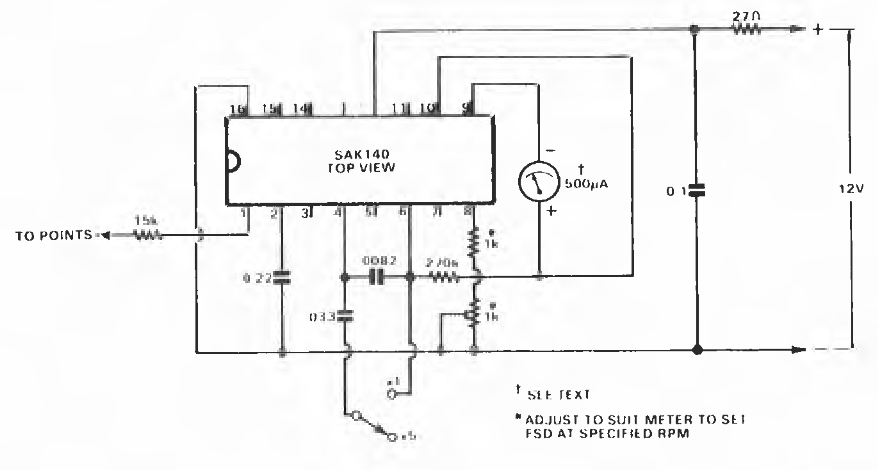
Note: Engines run to high rpm in neutral (or in gear on a trailing throttle) can throw a piston due to the relative lack of gas pressure in the cylinder during compression and combustion. Under normal loads, the gas pressure balances the high inertial forces applied by the piston at the top of the stroke.

At the heart of the tachometer circuit is an economy 16-pin dual in-line integrated circuit. It is the SAK140, supplied by Philips Elcoma.

The SAK140 is basically a monostable multivibrator which converts pulses from the contact breaker points into output current pulses of fixed duration and amplitude, to drive a meter movement. The complete circuit employing the SAK140 comprises only four resistors, three capacitors and one preset potentiometer.

Not a great deal can be gleaned about the operation of the SAK140 from its internal circuitry so we have not included the diagram with this article. The IC is protected against reverse supply connection and will operate at voltages from 10 to 18V with little variation in accuracy.

Input signals to pin 1 are clipped by an internal zener diode and high frequency components are attenuated by the 0.22uF bypass capacitor connected to pin 2. Duration of the pulses fed to the meter is determined by the 270k resistor connected between pins 10 and 6 and the capacitor connected between pins 4 and 6. The values of these components are selected to give the longest possible pulse length consistent with the maximum pulse repetition rate. If the pulse rate is too high or the pulse duration too long, the IC "blocks" and no output is delivered to the meter. When the tacho is switched to the 5000

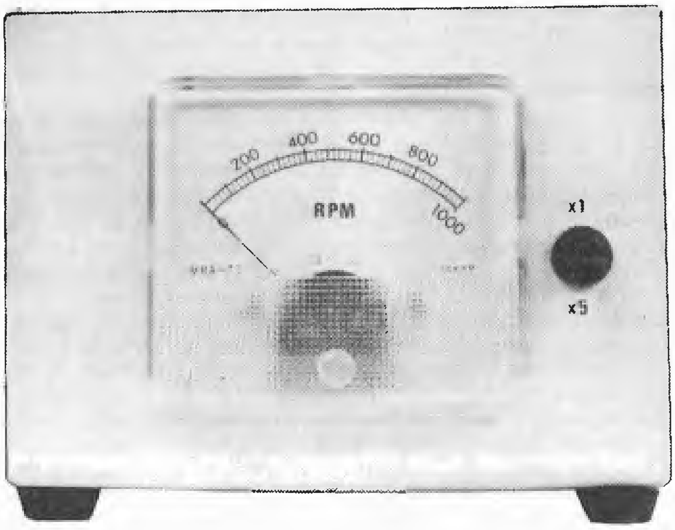


† SEE TEXT

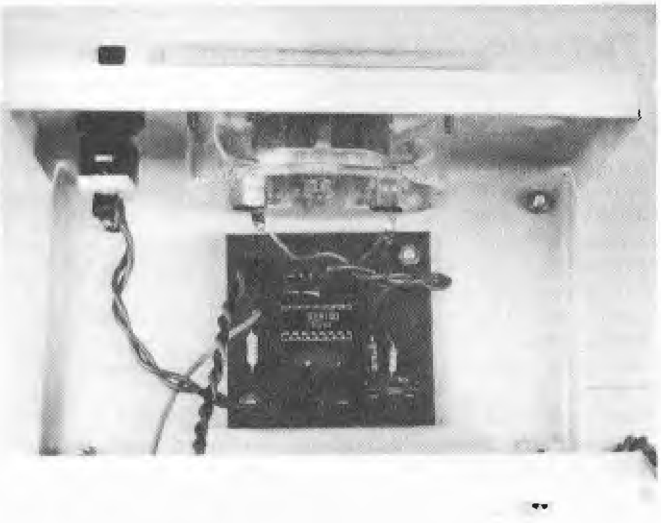
* ADJUST TO SUIT METER TO SET FSD AT SPECIFIED RPM

TUNE UP TACHOMETER

3/TM/11



A metal chassis was used to house the prototype.



Above shows the PC board installed in the chassis.

rpm range, the .0082uF capacitor is in circuit. When the 1000 rpm range is used, the .033uF capacitor is switched in parallel with the .0082uF to multiply the capacitance by very close to 5 times.

Strictly speaking, the .0082uF and .033uF capacitors should be very close tolerance units so that the error in switching from one range to another is as small as possible. In practice, it does not really matter since accuracy of the 5000 rpm range is not at all critical.

Virtually any meter movement can be used with the SAK140 provided it has a FSD sensitivity of 10mA or less. The circuit is adjusted to suit the meter sensitivity by selecting the components associated with pin 8. Our circuit suits a meter with a FSD sensitivity of 500uA but meters of 1mA sensitivity can also be used without any circuit change. If meters with lower sensitivity are used the preset pot and 1k resistor should be reduced in value. Minimum resistance from pin 8 to negative should not be less than 100 ohms.

Note that constructors will have to label the meter movement with suitable calibrations and "RPM" title using Letraset rub-on lettering. Unsuitable calibrations can easily be removed with a typewriter eraser.

One of the advantages of this tacho circuit is that it will function with conventional or capacitor discharge ignition systems without any modification being necessary. In both cases, the input pulses to pin 1 are taken from across the distributor points.

The tacho is normally powered from the vehicle battery, but where it is to be used with 6V vehicles it will have to be provided with its own 12V supply. In the former case, three clip leads will be required to make connection to the vehicle battery and to the points side of the ignition coil. In the latter case, two clip leads will be required, one connecting to the points as before and one to the negative post of the vehicle battery.

We assembled the prototype into a small chassis which we had on hand but we imagine that for a project of this simplicity a cabinet or chassis made from a few scraps of timber would suffice. If the chassis is made of metal it should be connected to the battery supply line which is normally connected to the vehicle chassis.

This latter measure prevents hash picked up by the metal chassis of the tacho from causing erratic and erroneous readings.

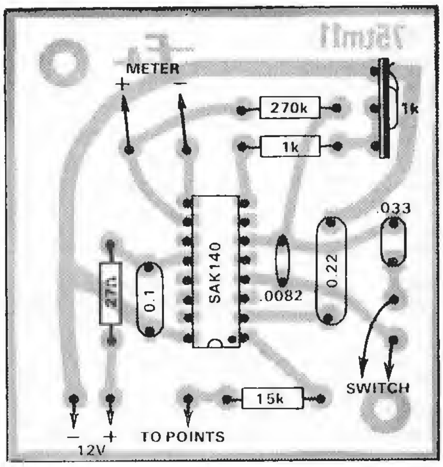
A small PC board measuring 57 x 60 mm accommodates the circuit components. Assembly is straightforward. We used a socket for the integrated circuit but this is optional. Resistors may be ¼ or ½W rating, except for the 15k input resistor which should be a ½W type to provide a rating of 250V.

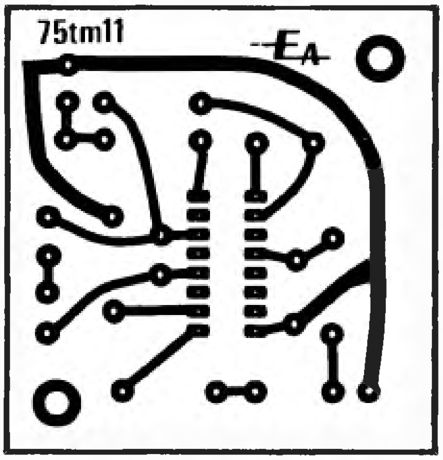
Any general-purpose SPST toggle switch may be used for the range switch. The type we used was one of the McMurdo 475 series.

Capacitors used were metallised polyester types but the 0.1uF and 0.22uF bypass capacitors could be low-voltage ceramic types. Component tolerances are not of any particular importance except for the .0082 and .033uF capacitors, as noted above. Unless you particularly

TACHO PARTS LIST

1 chassis (see text)
1 PC board, 57 x 60mm, code 75tm11
1 SAK140 integrated circuit
1 500uA FSD meter movement
1 SPST switch
1 .0082uF metallised polyester capacitor
1 .033uF metallised polyester capacitor
1 0.1uF metallised polyester or low voltage ceramic capacitor
1 0.22uF metallised polyester or low voltage ceramic capacitor
(½ or ¼W resistors)
1 x 27 ohms, 1 x 1k, 1 x 15k/½W
1 x 270k
1 x 1k preset potentiometer





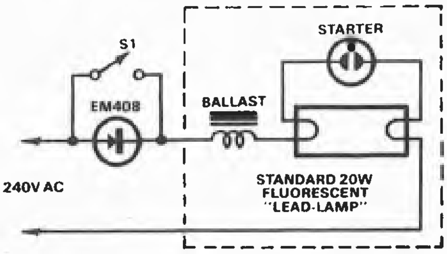


Fig. 2 above is the circuit of a "strobe" for calibration.

Tacho for tune-ups

desire high accuracy on the 5000 rpm range, 10 percent tolerance capacitors will suffice. Calibrate the tacho on the 1000 rpm range which is where accuracy is required for idle speed adjustments.

Calibration presents the biggest problem in this constructional project. Perhaps the easiest way is to calibrate it in comparison with a tachometer of known accuracy. This would rule out many of the cheaper automotive tachometers with 270 degree meter movements since their accuracy would be doubtful below 1000 rpm.

A more accurate and repeatable method of calibration is to connect the tacho to a vehicle and then use a fluorescent light to act as a strobe light at 50Hz. A standard garage fluorescent "lead-lamp" would be ideal for the purpose and the inclusion of a diode as shown in the circuit of Fig. 2 enables it to deliver 50Hz light pulses instead of 100Hz under normal conditions.

When the modified lead lamp is first turned on the diode should be out of circuit until the lamp lights fully. Then the diode is switched in to provide 50Hz operation. Note: we do not recommend that the lamp be used in this mode for long periods. The diode should be a power type with a reverse voltage rating of at least 800V.

50Hz corresponds to a crankshaft speed of 3000 rpm so at this speed, the vehicle timing pulley would appear stationary. Similarly, a check can be made at 1500 rpm by painting two white marks on the pulley (diametrically opposed). Four such marks will appear stationary at 750 rpm. Use the speed of 750 rpm to calibrate the 1000 rpm range. Just tweak the present pot until the meter reads correctly.

Finally, we should mention that this circuit can be adapted for use as a dash-mounted tachometer without any component changes other than to suit meter sensitivity, as mentioned above. As it stands, (with the .0082uF capacitor) the circuit is suitable for spark repetition rates up to 400Hz, which is equivalent to 6000 rpm for a V8, 8000 rpm in a 6-cylinder and 12,000 rpm in a 4-cylinder engine.

Calibration procedure is the same as before except that it should be optimised for readings at 1500 and 3000 rpm.

Footnote: An alternative, and fairly accurate method of calibration is to use the mains as a frequency reference. Apply a 10-20V AC signal to the input and adjust the present pot so that the meter reads 1000 rpm (full scale on the low range) for 6-cylinder engines, and 750 rpm for 8-cylinder engines.

The corresponding reading for 4-cylinder vehicles is 1500 rpm, in which case the meter scale will have to be recalibrated to read 1500 rpm full-scale on the low range and 7,500 rpm on the high range.

Another alternative is to modify the circuit to give a 4:1 range change instead of the original 5:1 change. This can be achieved by using a 3-pole 2-position switch to switch a pair of .022uF polyester capacitors in series/parallel combination between pins 4 and 6.

The original timing capacitors (.033uF and .0082uF) are omitted.

The two ranges can now be 0-1500 rpm and 0-6000 rpm (capacitors in parallel and series respectively). Calibration can be effected from the mains as described previously. □

Model Train Signalling System

One of the most useful devices for the model railway enthusiast is the reed switch, a simple and extremely reliable unit which can be located between the rails of a track and used to sense the passing of a train. A small magnet mounted under the loco will trip these switches. One very obvious application is to operate an automatic signalling system.

A suitable system is shown in the accompanying circuit. It is based on a two-transistor configuration called a "flip-flop", one being needed for each signal.

It uses a basic signalling system employing two coloured lights — red for stop and green for go — and any signal remains on green until a train passes it, whereupon it changes to red. It remains on red until the train has cleared the next section of track, that is, up to the next signal. When the next signal changes to red the first signal reverts to green. The reed switch senses the movement of the train past each signal and switches the signals accordingly.

Each reed switch is connected to two flip flops, isolated from each other by silicon diodes. These diodes stop unwanted interaction between signals behind the train.

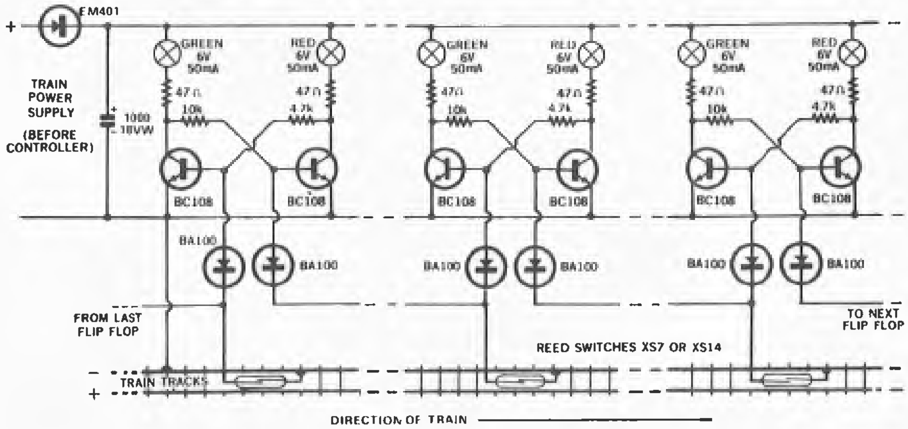
When the train passes over the reed switch, the contacts close, connecting together the base and emitter of the associated transistors. The forward bias is removed, cutting each transistor off and forward biasing its partner.

Because the two flip-flops are connected in the opposite sense, when one triggers from green to red, the others goes from red to green. The first one — green to red — will be the one the train has just passed. The second one will be the one further down the track behind the train. Any number of these signals can be installed around the track, each with its own flip-flop.

For those who may not have come across the reed switch before, it is a pair of contacts totally enclosed in a glass envelope, actuated by an external magnetic field, such as a permanent magnet.

Of the two reed switches specified — XS7 and XS14 — the XS14 is to be preferred as it is very much smaller than the XS7 and more readily accommodated and concealed between the rails.

The magnets to operate the reed switches need to be carefully selected. Ordinary types, such as available at department and novelty stores are usually much too weak. It is desirable that the reed switch be kept closed as long as possible as the magnet passes over it, and a strong field is desirable. We suggest the Plessey Rola FM448. The magnet can be glued to the underside of the loco tender.



The interlocked signalling system. Unequal resistors in the transistor base circuits (10k and 4.7k) ensure that the system comes up "all green" at switch-on. Power may be taken from the train power supply, ahead of the controller.

Build this fascinating game of chance

An electronic roulette wheel

Are you interested in games of chance? If so, then our Electronic Roulette Wheel is the thing for you. Fully solid state, and functioning in a suitably random manner, it will keep you amused for hours at a time.

by DAVID EDWARDS

Man has always been fascinated by games of chance, and one of the most popular forms of this mania is the wheel of fortune. Ranging from the simple chocolate wheel as used at fetes, to the complicated machines employed by casinos, these devices always seem to attract large crowds of people willing to "have a go".

Much care is required in the construction of these machines, to ensure that the wheel runs true, so that the final result is completely random, and not biased in any way. Anyone who has seen a roulette wheel in a casino will appreciate the skill and workmanship required.

Our Electronic Roulette Wheel has no moving parts, and thus does not require the same skills in construction. It is based upon an electronic number generator, which cannot be "fiddled" in any way. Admittedly, it does not have the same visual appeal as a large wheel which gradually slows down before stopping at the final number, but at the same time it is considerably less expensive, and does have a visual appeal of its own.

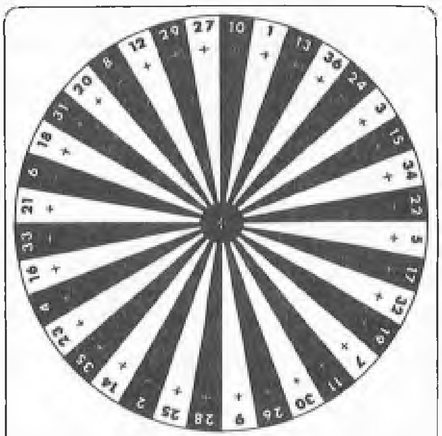
As you can see in the photographs, our unit consists of a fairly large box, fitted with thirty-six small lights, arranged in a circle. The circle is divided into alternate black and white segments, with each segment being numbered at random from one to thirty-six. Only one of these lights is illuminated at any one time.

When the PLAY button is pressed, the lights appear to move rapidly round the circle. Once the button has been released, the lights start to slow down, just like a true roulette wheel, and eventually come to a stop at some randomly selected number.

Fig. 1 is a block diagram explaining the way in which we have implemented the necessary functions. The clock generator is controlled by the PLAY switch. When the switch is depressed, the oscillator runs at a high speed, and feeds pulses to the divide-by-eighteen counter. After the switch is released, a time constant in the clock circuit makes the clock slow down to a stop in about 14 seconds.

The outputs from the counter are fed to a decoder, which has eighteen outputs. These are normally high, and each one goes low in turn as the counter cycles through its states. When the counter has reached eighteen, it is reset, and starts counting again.

This reset signal is also used to trigger a flip-flop, which thus changes state every time the counter re-cycles. The complementary outputs from the flip-flop are used to gate the outputs from the decoder, so that only one of the lamps connected to each decoder output is energised at a time. When the Q output of the flip-flop is high, lamps 1 to 18 are energised sequentially. The counter then resets, the flip-flop changes state, and lamps 19 to 36 are energised sequentially. The cycle then repeats for as long as clock pulses are supplied.



The front panel of our roulette wheel. Full size dyeline copies, positive or negative, are available, price $2.00.

Physically, the lamps are arranged in a circle, so that each one is illuminated in turn. Visually, the energised light appears to be rotating in the same way as a normal roulette wheel does.

Initially, when the clock is running at a high speed, it is impossible to distinguish between individual lights, all one sees is a blur of light in a circle. However, as the clock shows down, one is able to see a rotating pattern, until eventually, the individual lights can be seen. Finally, only one light will remain illuminated.

This final light is randomly selected because it is impossible to ascertain exactly when the PLAY switch is released. This uncertainty is due to the high initial clock speed. Extensive (and time consuming!) tests with our prototype failed to show any bias whatsoever.

Since our design is only capable of providing an even number of digits we decided not to have any zeros on our wheel. Zeros are normally provided to give a bias in favour of the casino. Having no zeros means that our wheel will not favour the banker over any player.

We decided to use TTL logic to implement our design, on the grounds that it is readily available, economical, and is capable of driving light emitting diodes (LEDs) directly. Although it has a high power consumption, we felt that for a mains powered device, this would not be too great a disadvantage.

The other main decision to be made concerned the type of lights to be used. While incandescent lamps are quite cheap, they are not capable of interfacing directly with TTL logic, due to their high current drain. In this respect LEDs are quite suitable, their only disadvantage until recently being price, particularly where, as in our case, large numbers were required.

Fortunately, in recent times, the price of LEDs has fallen drastically. They are now selling, in quantity, for less than 20c each. In some cases this includes a mounting kit for each LED. This is very good value.

Having decided on the general scheme of things, as described above, we were then faced with realising our design. Implementation of the clock generator did not prove difficult. As you can see from Fig. 2, we have used a type 566 function generator.

This is a voltage controlled oscillator with both triangle and square wave outputs. The basic oscillator frequency is set by the resistor connected to pin 6, and the capacitor connected to pin 7. With the values we have used, this gives a frequency of about 1700Hz.

The frequency is also influenced by the voltage on pin 5. With the PLAY switch pushed, this voltage is a minimum, and the frequency is a maximum. When the switch is released, the 220uF capacitor commences to charge. This increases the voltage, and progressively lowers the frequency, until the oscillator stops completely. This takes about 14 seconds.

The recommended supply voltage for the 566 is 12V, and the current drain about 10mA. This is quite easily provided, but more about that later.

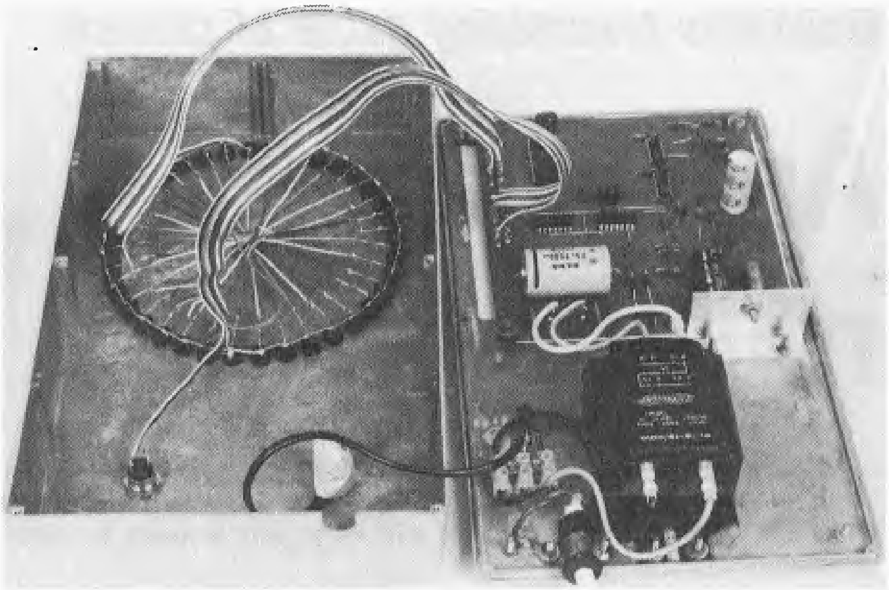
The square-wave output from pin 3 must be conditioned to suit TTL logic levels. This is done by the BC548 NPN transistor. The conditioned clock signal is then applied to the input of a 7493 type 4-bit binary counter.

This is converted into an eighteen stage counter by the addition of a J-K flip-flop and a 3-input NAND gate. The flip-flop is clocked from the output of the 7493. The NAND gate is used to generate a signal when the nineteenth count is reached, and this is used to reset the counter to the zero state. An inverter is necessary between the clear input of the flip-flop and the preset input of the counter, while two series inverters are used to "stretch" the reset pulse to ensure reliable operation.

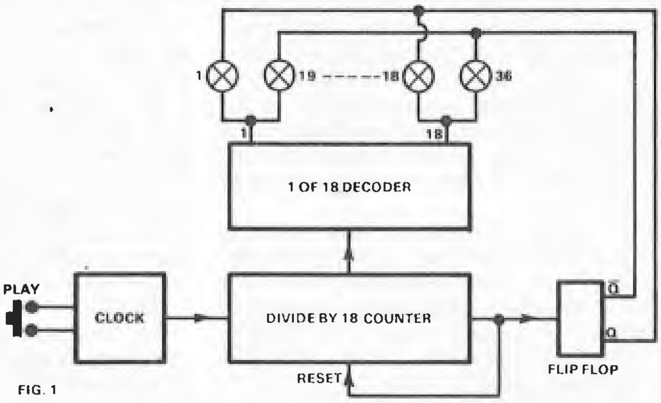
The eighteen line decoder is formed from a 74154 MSI 4-line to 16-line decoder, in conjunction with two 3-input NAND gates and two inverters. A signal applied to the strobe input of the 74154 disables it during the seventeenth and eighteenth counts, preventing spurious outputs.

Two small signal PNP transistors are used to buffer the output of the flip-flop used to select either of the two groups of LEDs. Resistors (120 ohms) in the collector leads serve to limit the LED current to about 20mA.

The configuration adopted is quite economical in terms of package utilization, only 6 ICs are used, and all of these are used fully except for one inverter. Total current drain of the circuit is about 130mA, from a 5V rail.



This picture gives a good idea of the complete layout. Note the "L" shaped bracket, to the right of the power transformer, which supports the BD135 transistor. The wiring board is mounted on spacers, with a sheet of cardboard beneath it as a precaution.



Block diagram of the roulette wheel. Pulses from the clock are fed to the divide-by-18 counter and thence to the decoder. The flip-flop converts the 18 outputs to 36 outputs for the LED display.

PARTS LIST

SEMICONDUCTORS

1 74154 1-of-16 decoder

1 7493 4 bit binary counter

1 7473 dual J-K flip-flop

1 7410 triple three-input NAND gate

1 7404 hex inverter

1 566 function generator

1 BD135 NPN power transistor, or equivalent

1 BC548 NPN transistor, or equivalent

2 BC558 PNP transistors, or equivalents

4 EM401 silicon diodes, or equivalent

37 LEDs, with mounting clips. See text

1 5.6V 400mW zener diode, BZX79C5V6 or equivalent

1 6.8V 400mW zener diode, BZX79C6V8 or equivalent

CAPACITORS

1 2500uF 25VW pigtail electrolytic

1 1000uF 16VW pigtail electrolytic

1 220uF 16VW PCB electrolytic

1 100uF 10VW pigtail electrolytic

3 0.1uF plastic

2 0.047uF ceramic

1 0.039uF plastic

2 0.001uF plastic

RESISTORS (½ watt rating)

6 10k, 1 2.7k, 2 2.2k, 1 1.5k, 1 1k, 1 150 ohm, 2 120 ohm, 1 100 ohm, 1 10 ohm

MISCELLANEOUS

1 printed circuit board, coded 76rt3, 140 x 140mm

1 transformer, 240V to 12V, PL12/20VA or equivalent

1 diecast box, 170 x 272 x 55mm

1 front panel, see text

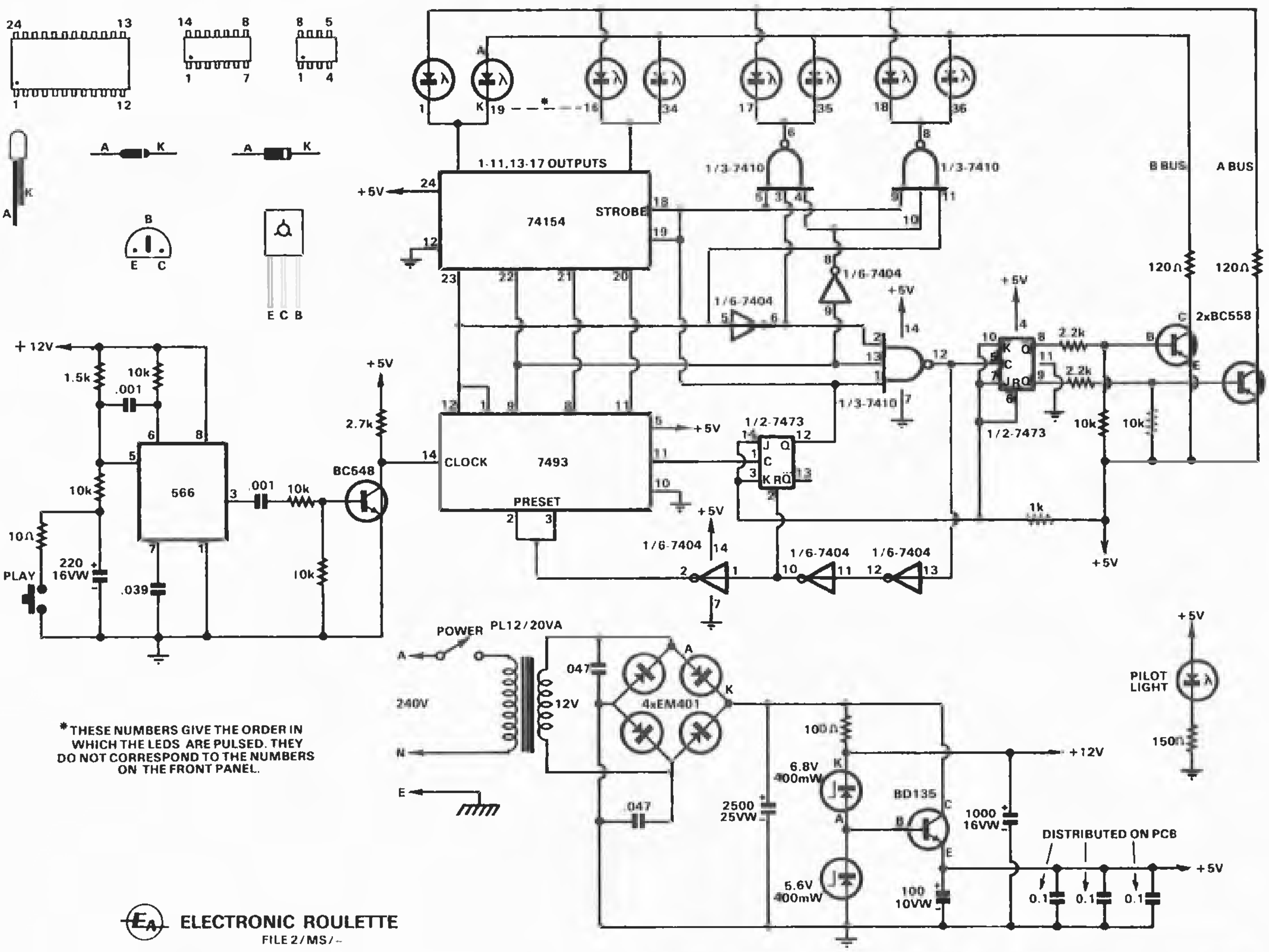
1 240V rated, push on-push off switch

1 N/O momentary contact push switch to match

1 mains plug, 3-core flex, grommet, cord clamp and 3-way terminal block

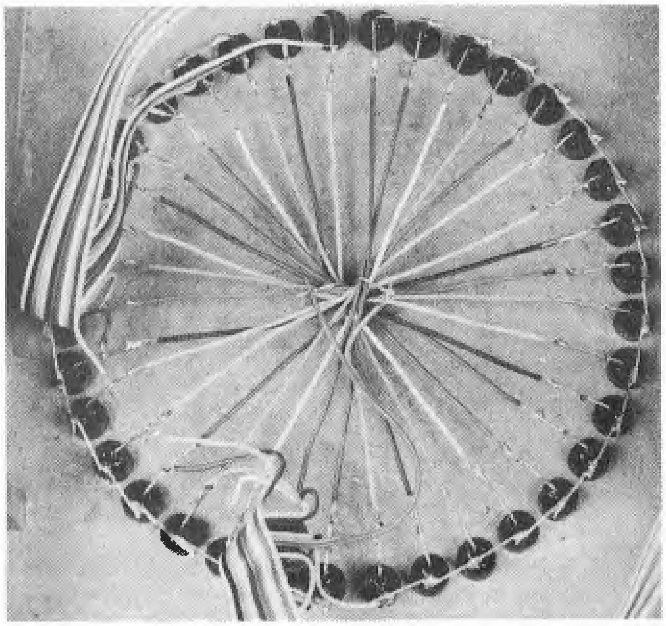
4 rubber feet

Scrap aluminium, machine screws, nuts, washers, solder, hookup wire, rainbow cable, mica washer, silicon grease, circuit board pins



*THESE NUMBERS GIVE THE ORDER IN WHICH THE LEDS ARE PULSED. THEY DO NOT CORRESPOND TO THE NUMBERS ON THE FRONT PANEL.

The complete circuit of the roulette game. Note that, for clarity, not all 36 LEDs are shown. The numbers next to the various circuit elements are the IC pin numbers.



A close-up of the LED wiring. All the cathode leads point towards the centre of the circle and are bridged to the cathode of the LED directly opposite. The anode leads are connected to form two semi-circles, each of 18 LEDs.

We have used a LED as a pilot light, and placed it in the centre of the circle of LEDs. While this is not strictly necessary, as one of the other LEDs will always be illuminated, we felt that it improved the look of the circle, by providing a point of interest at the centre. If desired, it can be deleted.

We have used a fairly simple power supply. A full-wave bridge rectifier feeding into a 2500uF electrolytic capacitor supplies a nominal 20V from a 12V rms transformer. Two 400mW zener diodes in series provide nominal outputs of 5.6V and 12.4V. The latter is used to power the 566 clock generator direct. Extra filtering for this is supplied by the 1000uF electrolytic capacitor.

The 5.6V zener drives a series pass transistor, giving a nominal output of 5V. This is stabilised by the 100uF electrolytic capacitor at the output. We have used one of the plastic type transistors, as this is easily mounted on a suitable heatsink. The collector-emitter power dissipation is approximately 2 watts.

We mounted our prototype in a standard die-cast box, measuring 170 x 272 x 55mm. As can be seen in the photographs, we mounted the LEDs on the bottom of the box, towards one end. We used two push switches, identical in appearance, for the POWER and PLAY functions.

We made a front panel for our device using "Scotchcal" photosensitive aluminium. We anticipate that kitset suppliers will be able to make available ready-made front panels. Alternatively, we can supply through our Information Services copies of our artwork. These are full size transparent dye-lines, suitable for use in making bromide prints by the contact method. We suggest that fairly "contrasty" paper is used. (Priced $2.00.)

Construction should be relatively simple, as all major parts are mounted on the printed circuit board. This is coded 76rt3, and measures 140 x 140mm. There

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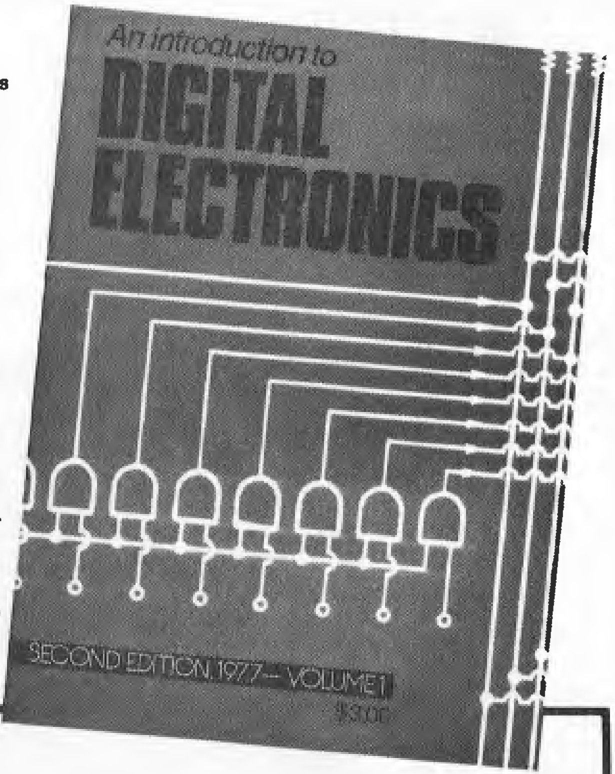


Here are the chapter headings:

1. **Signals, circuits and logic**
2. **Basic logic elements**
3. **Logic circuit "families"**
4. **Logic convention and laws**
5. **Logic design: theory**
6. **Logic design: practice**
7. **Numbers, data & codes**
8. **The flipflop family**
9. **Flipflops in registers**
10. **Flipflops in counters**
11. **Encoding and decoding**
12. **Basic readout devices**
13. **Multiplexing**
14. **Binary arithmetic**
15. **Arithmetic circuits**
16. **Timing & control**

Glossary of terms

are eight wire links on the board, which need not be insulated. The three electrolytic capacitors in the power supply must be pigtail types, rather than PCB types, as the headroom is limited.

The series pass transistor for the power supply mounts in one corner of the board. A small "L" shaped heat-sink must be fashioned from aluminium. The transistor is mounted on this with a mica washer and heat-sink compound. The heat-sink is then screwed to the case, with a little heat-sink compound ensuring a reliable thermal bond.

All other components can be soldered directly on the board. We suggest that the ICs are left until last, to minimise the risk of overheating. Remember to check the polarity of critical components, such as diodes and electrolytic capacitors. Use circuit board pins for all external connections to the board.

Once the PCB is completed, it can be mounted on the lid. The transformer is mounted centrally at the other end, as shown in the photographs. The mains cord enters through a grommeted hole, and is then clamped to the lid. File a "U" shaped slot in the edge of the case, so that the lid and bottom may be separated without disturbing the cord clamp.

The earth lead is terminated at a solder lug, screwed to the lid. The active and neutral leads go to the terminal block, and hence to the transformer primary via the power switch. Wrap the terminals of this switch with insulating tape, to eliminate a possible shock hazard.

The LEDs can now be mounted in the case. Use the front panel as a template to drill the required 6.35mm (¼ in.) holes. Care is required, to ensure that the template does not move during drilling.

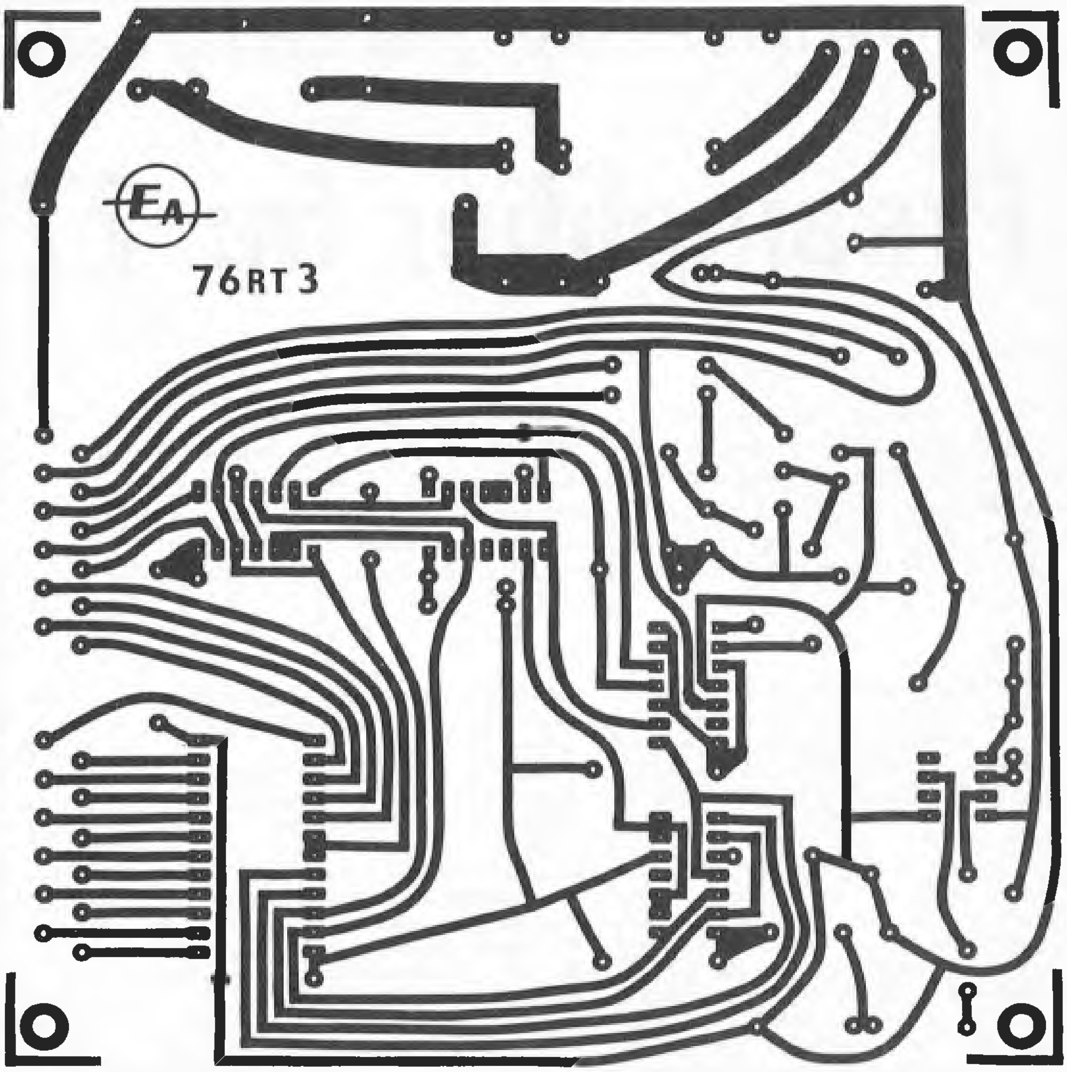
Mount the LEDs in position, using the clips supplied. Orient them so that the anode leads all point radially outwards. This will enable them to be bent as shown in the photograph, so that the "A" and "B" busses can be formed without any additional wiring. There must be eighteen LEDs in each buss.

The cathode leads are bent radially inwards, and short lengths of hook-up wire used to connect diagonally opposite LEDs. Commence wiring from the end of one buss, and work around the circle. Once this has been done, only the wiring to the PCB remains to be completed.

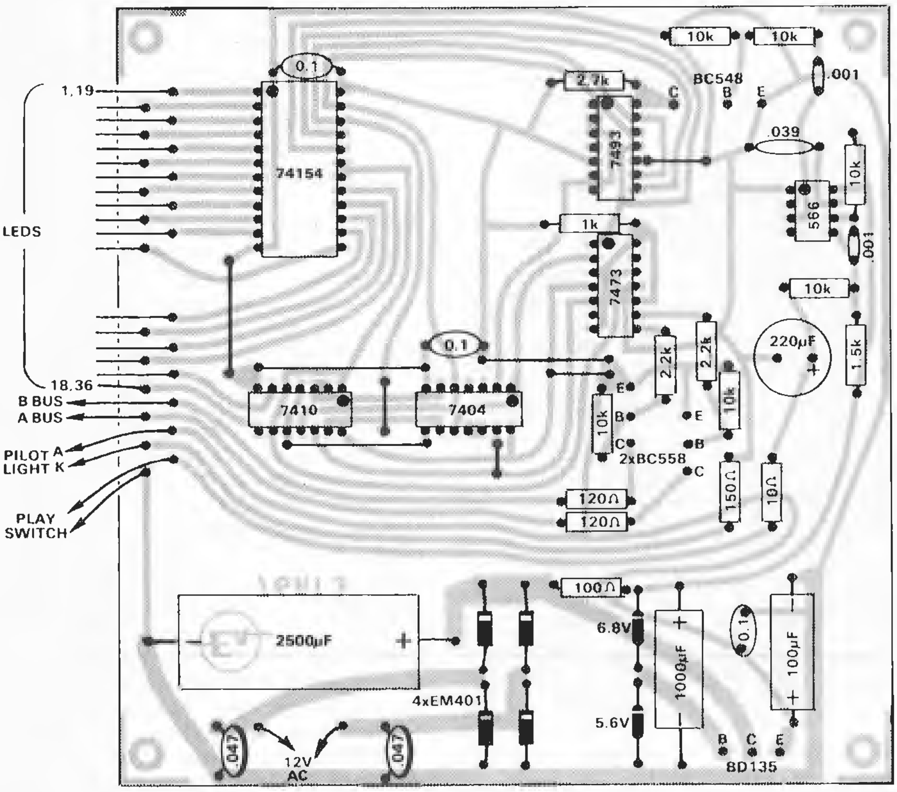
There are 24 connections from the PCB to the LEDs, and these have been grouped in two lots of twelve. We recommend that 12-way rainbow cable is used for these connections, in the interests of neatness and ease of wiring. Two 250mm lengths are required.

The eighteen wires from the PCB labelled "LEDs" must be connected to the eighteen cathode leads. Start at the clockwise end of one buss, and join the cathode of this LED to the first pin of the PCB (i.e. the pin connected to pin 1 of the 74154). Then, working anticlockwise around the LEDs, connect the cathodes sequentially to the circuit board pins. The

Right: The printed board pattern shown full size. As usual, copies of this pattern have been distributed to the board manufacturers and ready made boards should be available from your dealer.



Below: The component layout on the board, shown from the component side. Pay particular attention to the polarity of diodes, electrolytic capacitors, etc., and also to the correct orientation of the ICs.



cathode at the end of the buss should connect to pin 8 of the 7410.

The next two wires from the PCB connect to the two busses. Either wire can be connected to either buss. The next two wires connect to the centre LED. Make sure that the lead marked "anode" is connected to the LED anode. The remaining two wires connect to the PLAY switch.

Construction is now complete, and the machine can be tested. On intitial turn-on, the LEDs should all be flashing sequentially. They may take a little longer than normal to stop, as the 220uF electrolytic capacitor is re-formed.

When the PLAY swith is operated, the LEDs should all appear to be on. As the oscillator slows down, a clockwise rotation will become evident, and eventually only a single LED should be on. If required, the maximum oscillator frequency can be varied by changing the 0.039uF capacitor. The time taken for the oscillator to stop depends on the value of the 220uF capacitor.

You can now commence to play roulette using your unbiassed wheel. Copies of the rules and a cardboard table layout should be available from hobby and toy shops.

Get the most out of your CB rig with this

Preamplifier for 27MHz

Here is an excellent "home brew" version of a gadget which has proved particularly popular overseas with 27MHz—and 28MHz—operators. Operating from 12 volts and connecting directly in series with the coaxial antenna cable, it can boost weak incoming signals or attenuate excessively strong signals at the turn of a knob. Press the "transmit" button and it switches automatically to a straight-through connection.

by IAN POGSON

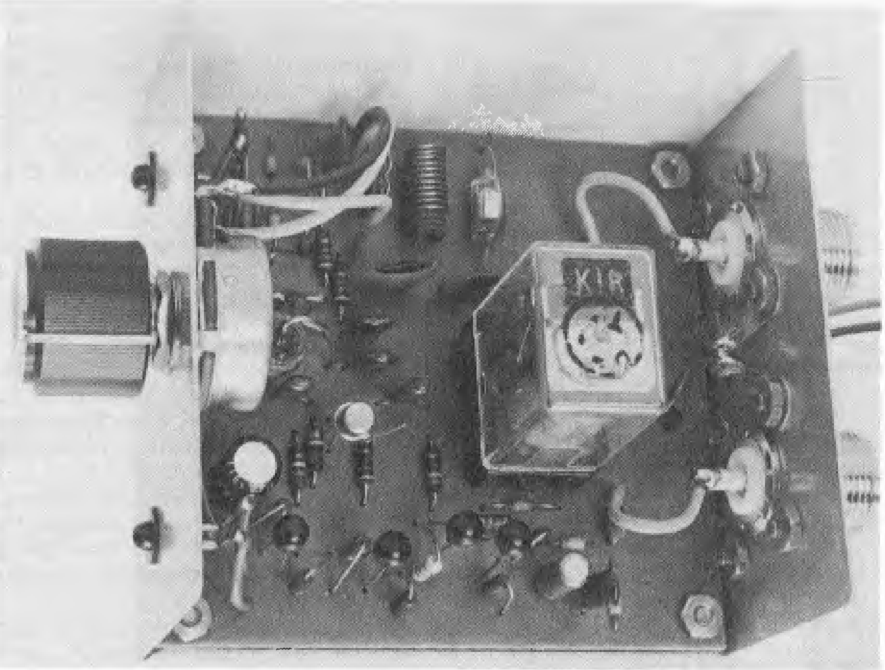
With large numbers of 27MHz transceivers being used at the present time, many of them can benefit to a greater or lesser extent from the addition of just such a preamplifier. The same is true, on a smaller scale, of 28MHz transceivers—and receivers.

The units likely to benefit most are the older or lower priced models where front end design, signal-to-noise ratio and overload characteristics are not what might be termed "state of the art". By adding a preamplifier with gain and a good signal-to-noise ratio, the effect can be quite dramatic; signals, down in the noise, suddenly become loud and clear. Alternatively, with the attenuator facility built into the preamplifier, strong signals which might otherwise cause overload problems, can be substantially reduced in level.

More expensive modern units, many of which have excellent signal-to-noise ratio and overload characteristics, stand to benefit less from the use of a preamplifier. Even so, some operators with these higher quality units declare that they have benefited by adding a commercial preamplifier, particularly where they are operating from a bad or remote location.

Mobile operators, of course, have to cope with a variety of problems: compromise antenna systems, acoustic and electrical noise in and around the vehicle, locations which vary from superb to terrible and "blotto" signals from a car which ranges alongside. Some transceivers are equal to the challenge; many are not.

Last but not least, there are many amateur band receivers and transceivers still in use, with valve or early transistor front ends. Performance usually droops markedly towards 30MHz and the addition of an external high-gain low-noise front end can likewise work wonders.



A single PC board accommodates most of the components, including the relay. The antenna socket is at top right, with the transmitter socket below.

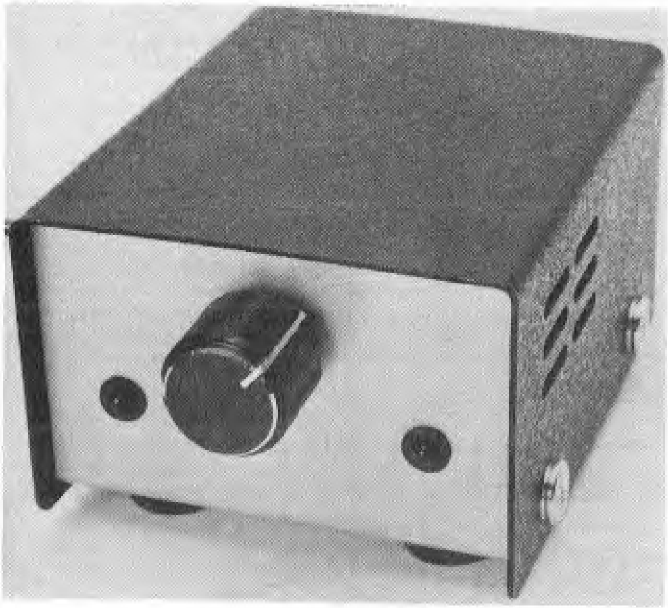
Commercially made preamplifiers are available on the market, which are well designed and built units. In spite of quite a high price tag, we understand that sales are brisk. However, if you would like to make one yourself, either to save money, or for the satisfaction of so doing, our new preamplifier appears to match up well with the commercial units.

To be of any real value, a preamplifier must have a useful amount of gain, while the signal-to-noise ratio must also be as good as may be achieved with reasonable cost and complexity. In addition, the signal handling ability should be such that it will cope with strong signals without overload, and there are times, as already pointed out, when it is desirable, to invoke attenuation rather than gain.

For convenience, a supplementary preamplifier should connect directly in series with the antenna coaxial feeder, processing all incoming signals but switching out of circuit automatically when the transmit button is pressed.

In the commercial units and our home-brew version, the changeover function relies on a high level RF sensing circuit coupled to a DC amplifier, which operates a relay. Two sets of contacts switch the preamplifier out of circuit during transmit, while an extra transistor simultaneously removes the supply voltage from the preamplifier.

With an AM transmitter, the relay remains energised while ever the press-



Our prototype 27MHz preamplifier has about 25dB of gain at one extremity of the control pot, and about 40dB of attenuation at the other.

PARTS LIST

1 Metal box, 83mm wide x 56mm high x 102mm deep
1 Printed board, 87mm x 79mm code 77pre5
1 Relay, 2 sets changeover contacts 185 ohms 12V
1 PCB socket for relay
1 470uH RF choke
4 Transistors, BC208, BC548, etc
1 Transistor, BF115, BF494, etc
1 Transistor, MPF131
5 Diodes, 1N4148, etc
1 Diode, EM401, etc
2 LEDs, type NSL5023 or similar, with bezel
1 Slug, Neosid grade 900 to fit 7.6mm formers
2 UHF coax sockets, type SO-239A
1 Knob

RESISTORS (½W unless stated otherwise)

1 100 ohms
1 470 ohms
1 560 ohms
2 680 ohms
1 1.2k
1 1.8k
1 4.7k
1 6.8k
1 10k
1 12k
2 22k
2 47k
1 220k
1 270k
1 10k log pot
1 50k subminiature trimpot

CAPACITORS

1 10pF NPO ceramic
1 47pF NPO ceramic
1 100pF polystyrene or NPO ceramic
1 220pF polystyrene
2 .001uF 100V greencap
5 .01uF 100V greencap
1 3.3uF 50VW electrolytic
1 47uF 16VW electrolytic

MISCELLANEOUS

Hookup wire, solder, solder lugs, rubber grommet, screws, nuts

Note: Resistor wattage ratings and capacitor voltage ratings are those used on the prototype. Components with higher ratings may generally be used providing they are physically compatible. Components with lower ratings may also be used in some cases, providing the ratings are not exceeded.

to-talk button is held down, because the carrier is present, irrespective of modulation.

In SSB mode, however, RF energy falls substantially to zero during silent periods, so that the relay may tend to drop out during the breaks between words. To prevent the relay from "chattering", time constants in the actuate circuit must be arranged so that the relay will hold in for about 1 second, sufficient to bridge any small breaks between syllables. If the operator pauses for longer than a second, allowing the relay to drop out, it must close as rapidly as possible at his next word, to avoid clipping the first syllable.

The circuit as shown meets these requirements very well, being voted by one operator as the best "vox" he had heard.

The unit, as pictured, is assembled on a printed board and there are no complicated parts to contend with. In short, no trouble should be encountered in building the preamplifier and getting it going.

Looking first at the preamplifier section, input from the antenna is fed via one set of relay contacts into a capacitive divider which forms a tuned circuit with a variable inductor. Signals from the tuned circuit are then passed to the first gate of a dual gate MOSFET, which is used because of its ability to handle large signals before overload, together with the possibility of realising a good signal-to-noise ratio. These features require careful arrangement of the DC operating conditions, which accounts for the rather unusual biasing circuitry.

Gain is controlled by varying the bias on the second gate by means of a potentiometer, a preset potentiometer being used to set the range of control.

The drain of the MOSFET is untuned, with a 470uH RF choke serving as the load. Signals emerging at the drain are transformed to a low impedance via an emitter follower. From the emitter follower signals then pass through another set of relay contacts to a second UHF coaxial socket and so to the transceiver (or receiver).

In laying out the preamplifier considerable care was taken to minimise the risk of feedback and instability. A point of concern is that both input and output have to pass through adjacent relay contacts but no difficulties were evident, probably because both circuits are at low impedance—nominally 50 ohms.

Turning now to the sensing circuit, in the "receive" condition there is no effective drive to the first BC208 and it is not conducting. As result, there is forward bias on the second BC208; in this condition, it deprives the third BC208 of forward bias and it is cut off. Since the relay winding is in the collector of this transistor, and as no current is flowing, the relay will remain at rest, leaving the preamplifier in circuit.

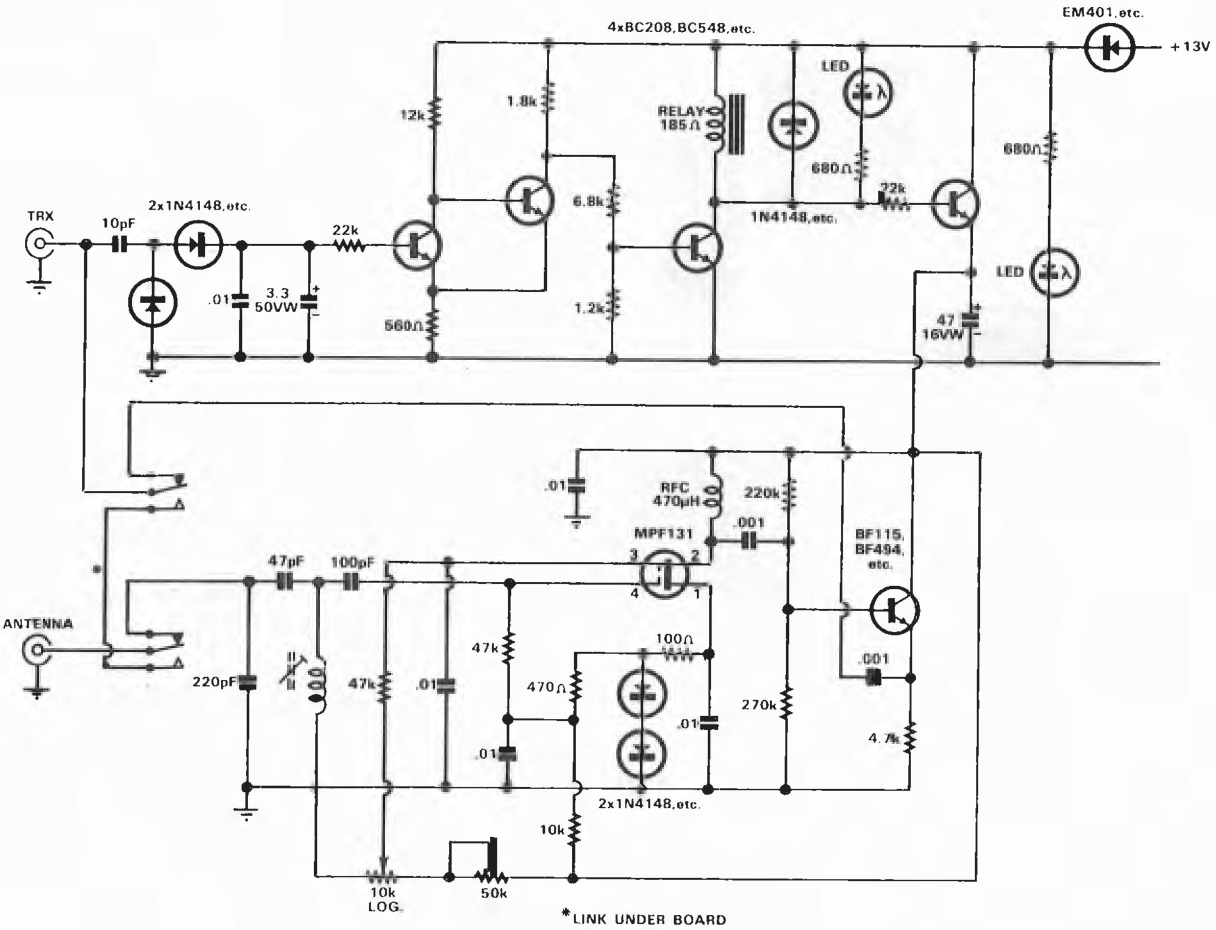
The fourth BC208 derives its forward bias from the collector of the third transistor and, in the "receive" mode, the fourth transistor is conducting. Being connected as an emitter follower, it provides the supply voltage for the MPF131 MOSFET and the BF115 emitter follower.

As soon as the transmitter is switched on, high level RF appears at the 10pF capacitor. It is rectified by the two 1N4148s, charging the 3.3uF and 0.1uF capacitors in parallel. This provides a source of forward bias via the 22k resistor and turns on the first BC208. In so doing, the following three stages reverse their former condition, resulting in the relay being operated. Simultaneously, the supply voltage is cut off from the RF amplifier and emitter follower output.

The changeover takes place very rapidly, in a matter of milliseconds.

When the transmitter is again switched off, the voltage across the 3.3uF capacitor continues to discharge for a time through the 22k resistor into the base of the first BC208, which continues to conduct. After about one second, the capacitor is discharged to the point where the transistor no longer conducts and the preamplifier becomes operative again.

Two light emitting diodes (LEDs) are used as indicators. One is across the supply, in series with a 680 ohm resistor and indicates that the power supply is on. The other LED, in series with a 680 ohm resis-



27-28MHz PREAMPLIFIER

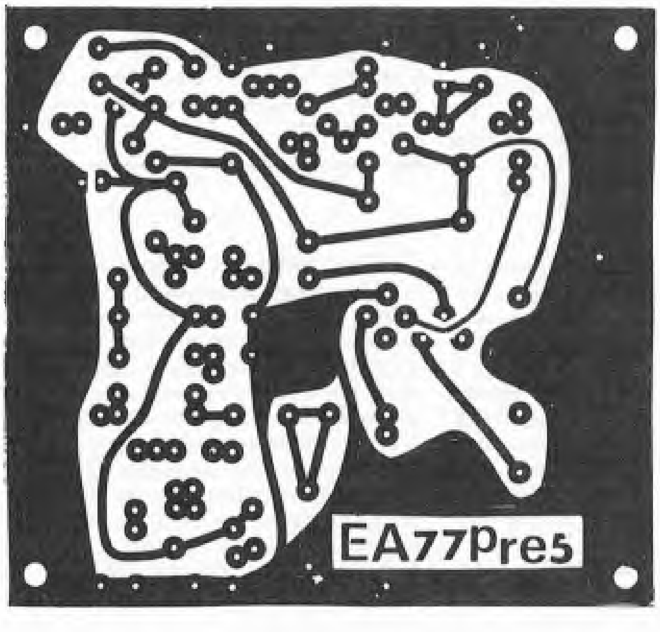
tor, is connected across the relay winding and glows under "transmit" conditions.

The 1N4148 diode across the relay winding is to protect the transistor from possible damage from spikes induced by the relay winding as the circuit is opened. The power diode at the input of the +13V supply is added as protection against the possibility of a reversal of supply voltage polarity.

All components specified are in normal supply at the time of writing. The box which we used is distributed primarily by Dick Smith Electronics but other components are routine items for most suppliers. If for any reason, you wish to use a different box, there is no reason why you should not do so, provided that the layout is not altered unduly. This applies particularly to the input and output leads and sockets.

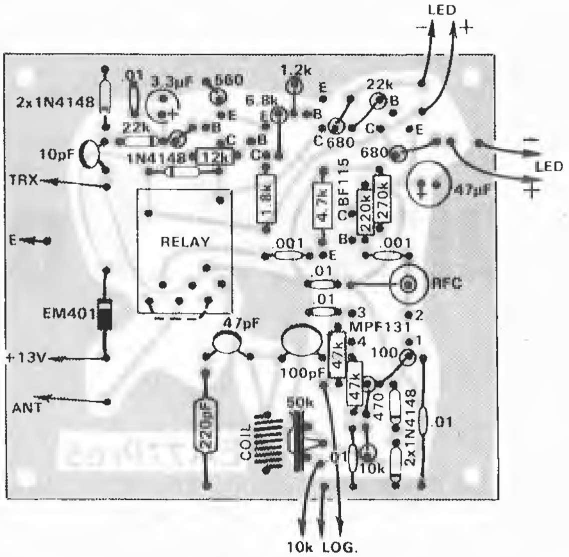
It was suggested by one of our staff that, in cases where it is desired to "broadband" the preamplifier for use on both 27 and 28MHz, the LC ratio of the input tuned circuit could be changed to advantage. It may be made broader by increasing the value of the inductance and reducing the effective value of capacitance across it. The inductance could be increased by adding an extra turn or two and by setting the slug almost right in. The effective capacitance would then have to be adjusted to give the required resonance. Note that the ratio between the two capacitors should be kept about the same as in the prototype.

Construction is fairly straightforward but the usual care should be taken not to overheat any components when soldering. Due to the fact that the board layout is rather compact, a little extra care may be needed. It is a good idea to fix the smaller components first, starting with the resistors, then diodes, capacitors, transistors, etc. Make sure that com-



Here is the PC pattern, reproduced actual size to allow tracing.

27MHz preamplifier



This component layout diagram shows the PC board as viewed from the component side. Take care to ensure correct orientation of polarity conscious components.

ponents requiring it are inserted with due regard to polarity.

The tuning coil consists of 11 turns of 22B&S enamel wire, wound directly on a Neosid grade 900 slug. The two ends should be bent so that, when bared and tinned, they will pass through the holes provided on the board. The slug should be left in the centre of the coil until the final adjustment stage.

Having fixed all components to the board, leads of sufficient length should be attached for the plus and minus supply, connections to the two coaxial sockets, including an earth lead, the two LEDs and the gain control. Note that a link of hookup wire must be added underneath the board, across the relay contacts as shown on the circuit.

The board assembly is now ready to be fitted into the box. Holes have to be driled to mount the board, together with holes for the gain control and LEDs on the front panel, and for the coaxial sockets and a grommet in the back panel.

With all the holes ready, the board should be mounted first, using four ⅛in Whitworth RH screws, ½in long, with the screw heads underneath. Three nuts are used on each screw to stand the board off the bottom of the box by about 8mm. Power supply leads are brought out through a grommeted hole on the back pañel, as mentioned earlier.

When fixing the two coaxial sockets on the back panel, a solder lug should be provided under each of the two top adjacent screws. The ends of the lugs are brought together and soldered and the earth lead from the board is terminated on these lugs. Leads are also run to the respective centre contacts of the two coaxial sockets.

It will depend upon the type of LEDs which you use as to how they are fixed to the front panel. With the type we used, we glued the main body of the plastic holder with Araldite to the back of the panel, dispensing with the "nut" as being rather too difficult to fit. The leads of the LED are bent at right angles, so as not to foul other components nearby, and connected to the board by the hookup wire leads already provided.

When fitting the gain control potentiometer to the front panel, it may be necessary to bend the RF choke out of the way.

At this stage construction is complete and it is only necessary to make a couple of adjustments before the unit is ready for use.

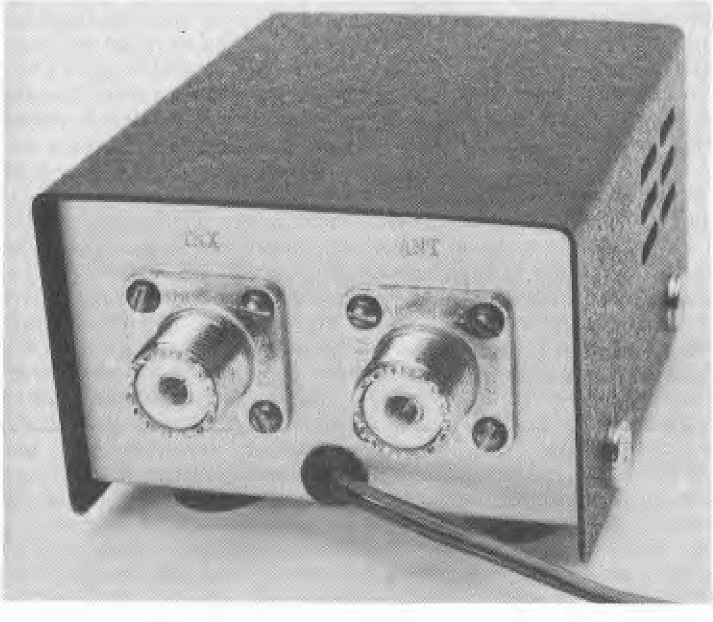
Set the gain control to maximum (rotor nearest the 50k trimpot) and set the 50k trimpot rotor to mid position. Connect a short cable between "TRX" socket and the transceiver. Connect the aerial feedline to the socket marked "ANT". MAKE SURE THAT YOU HAVE THESE CONNECTIONS CORRECT, OTHERWISE DAMAGE COULD RESULT. Connect the power supply leads to a source of 12 to 13.5V; current will range from about 25 to 90mA, depending on operating mode.

Switch on (the power supply LED should glow) and tune to an AM signal in about the centre of the band, say between channels 10 and 13. With an insulated aligning tool, adjust the slug so that it moves towards the 100pF capacitor, for maximum response on the receiver's S-meter. In our prototype the slug tuned from 25MHz full in to 30MHz well out.

Next, advance and retard the gain control and determine whether there is a "flat" part at the last of its travel towards maximum. If there is, increase the amount of resistance of the 50k trimpot in circuit until gain increases continually as the control is turned up fully. If no flat is evident, the 50k trimpot should have its resistance reduced until a flat portion is evident and the trimpot should be set back until the flat disappears.

In our prototype, we were able to confirm about 25dB of gain with the control fully clockwise and about 40dB of attenuation at the other extreme. By using a logarithmic potentiometer, the gain was spread conveniently over the arc of rotation, with unity gain occurring at about "2 o'clock".

The preamplifier is now complete and the cover of the box may now be fitted and the unit is ready for use.



Rear view of the prototype. Make sure that connections to aerial and transceiver are correct, or damage could result.

New, fully protected IC design

Regulated Power Supply

Using only a single integrated circuit, this little power supply can provide voltages up to 30V, and currents exceeding 2A. It is completely protected against excessive currents and thermal overloads, and has current and voltage metering. Best of all though, it's simple to build!

by DAVID EDWARDS

One piece of test gear that never goes astray on any experimenter's bench is an adjustable power supply. It seems in fact that you can never have enough of them, especially if they are fully regulated and protected.

In this article we present a design for such a supply, which uses a single IC. The output voltage is adjustable from about 1.2V to 30V, and output currents in excess of 2A can be obtained.

Our prototype has less than 1mV of output ripple and noise, while the output voltage changed by only 130mV when the output current was increased from 0 to 2A. It is completely stable under all load conditions, both capacitive and inductive.

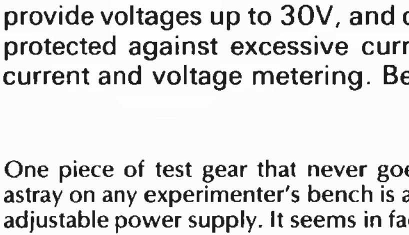


FIG. 1

This diagram shows how a three terminal regulator can be used as an adjustable power supply.

It also survived all manner of overloads. We short-circuited the output at full output voltage, and we connected fully charged electrolytic capacitors across it with the main supply electrolytic capacitors discharged, all without damage. It also withstood a fully charged capacitor connected similarly, but in the reverse mode. Attempting to draw full power with no heatsink also failed to damage it.

Refer to the accompanying graph for details of the load capabilities of the new supply. This is a graph of load voltage against maximum load current (at the onset of loss of regulation). As you can see, currents of up to 1A can be supplied at voltages between 3 and 25V. Higher currents can be supplied over a more limited range.

The limits of the curve are determined by the internal limits of the regulator IC and also by the regulation of the transformer. Note that this curve was measured using our prototype, and is only representative. Typical supplies may have slightly better (or worse) performances.

Heart of the design is a new National Semiconductor IC, the LM317 three terminal adjustable regulator. As well as being adjustable, the LM317 has better line and load regulation than standard three terminal regulators. Included on the chip are current limit, thermal overload and safe area protection circuitry.

Turning to Fig. 1, we can see how a three terminal regulator can be used as an adjustable supply, and why the LM317 is better at this job than a standard regulator. Any three terminal regulator acts to keep Vreg, the voltage between the output terminal and the common or adjustment terminal, constant.

Neglecting any quiescent current drawn by the regulator, and assuming that no current is drawn by the adjustment terminal, then a fixed current, given by Vreg/Ra, will be passed through Ra. This fixed current must also pass through Rb, and will hold the adjustment terminal at Rb. Vreg/Ra volts. Thus the output voltage will remain fixed at Vreg + Rb. Vreg/Ra volts, irrespective of variations in input voltage or output current.

However, normal three terminal regulators do draw quiescent current, and this upsets the performance of this sort of adjustable regulator. Regulators such as the LM309 or uA7805 pass a small, but by no means insignificant, quiescent current through the adjustment terminal. This current varies with input voltage and junction temperature.

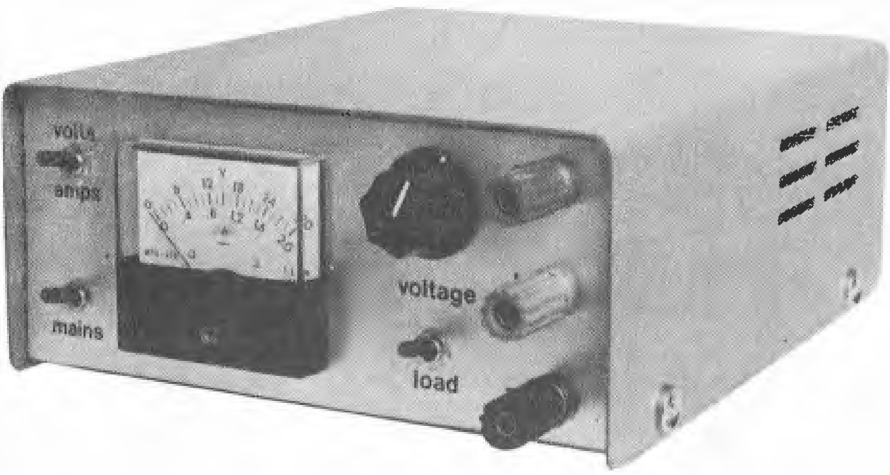
This current is added to the fixed current passing through Rb, and any variations in it cause corresponding variations in the output voltage, thus spoiling the ripple and regulation performance. A second problem is that since these types are nominally 5V regulators, the lowest output voltage which can be obtained is 5V. The upper limit to the output voltage is set by the maximum allowable input voltage of the regulator.

The new regulator which we have used in this project also draws a quiescent current from the supply, but differs from previous types in that this quiescent current comes out of the output terminal, rather than the adjustment terminal. The current drawn by the adjustment terminal is very small, of the order of 50uA.

A second difference is that the output voltage of the regulator is 1.2V, rather than 5V. These differences make a significant change in the way the regulator works. In the absence of a load, the quiescent current must pass through Ra and Rb. Ra must be chosen so that the maximum quiescent current which is drawn by the regulator will not produce a voltage drop across it in excess of Vreg (1.2V for the LM317).

Thus the regulator will maintain ts own quiescent current constant, so that the voltage drop across Ra remains fixed at Vreg. Since the current also flows through Rb, and since the current from the adjustment terminal is insignificant, the voltage drop across Rb will remain constant (but dependent on the value of Rb), so that the output voltage will also remain constant, irrespective of any changes in supply voltage, load current or temperature (within the limits of the regulator's performance, of course).

The minimum output voltage will be Vreg, as before, but this is now 1.2V. Maximum output voltage is still set by the



limits of the regulator. The minimum load current is still zero, as the quiescent current is passed by Ra and Rb.

Turning now to the main circuit diagram, Fig. 2, we can see how the complete supply has been implemented. The mains transformer is the same one as used in the new Twin Twenty-Five amplifier, and has a centre-tapped secondary rated at 44V and 2A. Two 2A 100PIV silicon diodes feeding 5000uF of capacitance are used to rectify and filter the output from the transformer.

The LM317 is connected as described earlier. Ra is formed by a parallel combination of two resistors, while Rb is a 5k linear potentiometer. With these values, the output voltage can be adjusted to above 30V. The 10uF capacitor connected across Rb improves the ripple rejection of the supply, while the diode connected between the OUT and ADJ terminals provides a discharge path for this capacitor when the supply is turned off.

The 1uF capacitor connected across the output ensures stability. The diode connected between IN and OUT terminals provides a discharge path for any external capacitors connected to the supply, and prevents damage to the IC itself. Output metering is provided by a 1mA meter, which can be switched to read either voltage or current.

In the voltage mode a 30k resistor formed by a parallel combination of 330k and 33k resistors is placed in series with the meter across the supply. The meter then reads 30V full scale. In the current mode, the meter is connected across a 0.47 ohm resistor inserted in the return line to the filter capacitors. A 1k trimpot is used to adjust the meter so that it reads 2A full scale.

A double-pole double-throw switch is used to open the connections leading to the output terminal, so that the external load can be disconnected. This facility is required because the supply cannot be set to zero volts.

The output of the supply is fully floating, with neither terminal connected to the earthed case. A terminal connected directly to the case is provided, so that either of the output terminals can be earthed if desired.

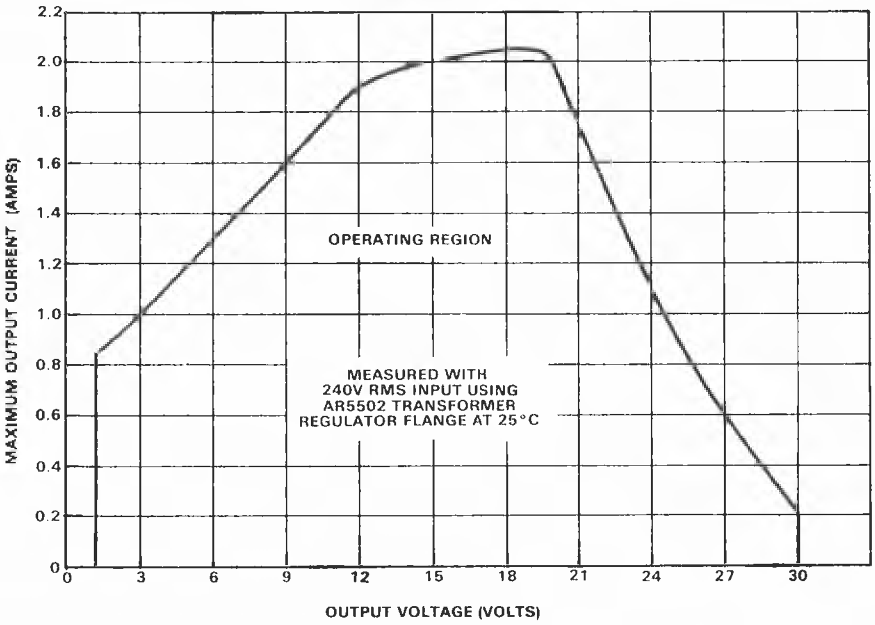
A diode has been shown (dotted) connected between the output terminals. This is an optional extra which will prevent damage to the supply in the event that a reverse voltage is applied to the output terminals.

Construction of the supply should be quite simple, as there are very few components. We mounted our prototype in a case supplied by Dick Smith Electronics. This has an aluminium chassis with a painted steel cover, and measures

PARTS LIST

1 LM317K adjustable three terminal regulator
2 2A 100PIV silicon diodes, 1N5408 or equivalent
2 1A 100PIV silicon diodes, EM401 or equivalent
1 transformer, 240V to 40V CT @ 2A, JT180, AR5502, PF3993 or equivalent
2 2500uF 35VW pigtail electrolytic capacitors
1 10uF tantalum electrolytic capacitor
1 1uF tantalum electrolytic capacitor
1 330k, 1 33k, 3.9k, 1 220 ohm ½W resistors
1 0.47 ohm 2W resistor
1 5k linear potentiometer
1 1k linear trimpot
3 DPDT miniature toggle switches
3 terminals, 1 red, 1 green, 1 black
1 case, 70 x 160 x 184mm; see text
1 heat-sink, see text
1 knob
1 1mA meter, 51 x 49 x 43mm
2 8-lug tagstrips, with 2 mounting lugs
1 4-lug tagstrip, with 1 mounting lug
1 mains plug, cord, grommet, cord clamp and terminal block
Solder lugs, solder, hook-up wire, tinned copper wire, machine screws and nuts, T03 insulated mounting kit, heat-sink compound

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with high ratings may generally be used provided they are physically compatible.



This graph shows the maximum voltage and current which can be obtained from the unit. The graph was derived from the prototype, and is only representative.

70 x 160 x 184mm. It is very reasonably priced at $3.60, and is supplied complete with rubber feet and cover attaching screws.

As can be seen in the photographs, the transformer is centrally mounted. Clearance must be left at the front for the panel meter and current adjusting trimpot, and at the rear for the electrolytic capacitors.

The mains cord enters through a grommetted hole in the rear left hand corner, and is clamped to the chassis. The earth lead is terminated in a solder lug, which is clamped to the chassis, while the active and neutral leads terminate in a 2-way terminal block. From there the mains is routed through the power switch to the primary of the transformer.

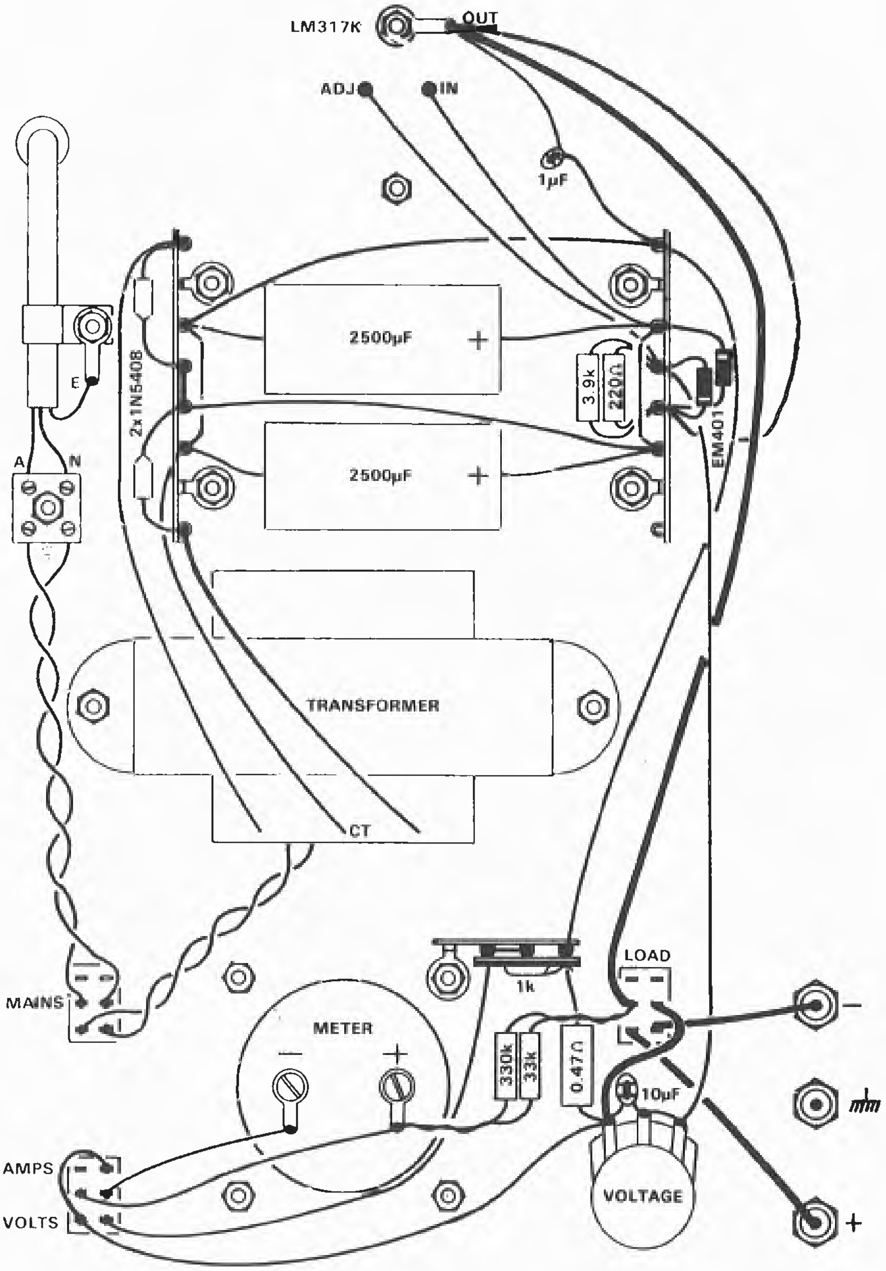
Mount the LM317 in the centre of the rear of the chassis. In order to gain maximum performance, a heatsink must be provided. We used a suitably bent piece of 18 gauge aluminium, thermally connected to the chassis and to the LM317 with heatsink compound. Remember that the LM317 must be insulated from the chassis. If desired, a commercial heatsink can be used.

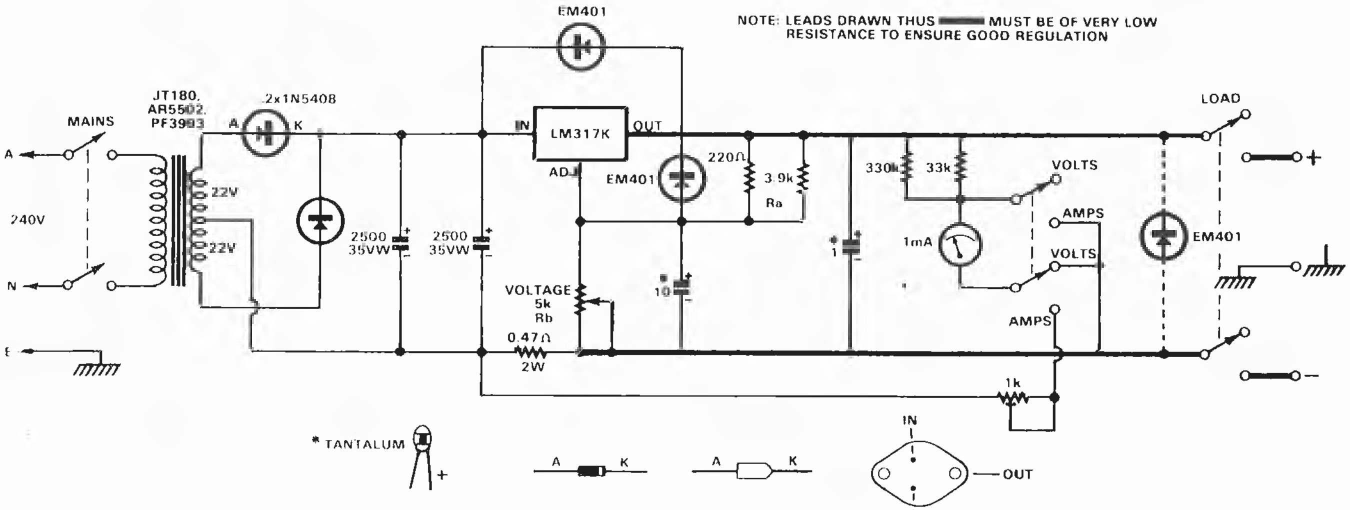
The remainder of the components can be positioned, and the wiring completed, with the aid of the wiring diagram. Use heavy duty hookup wire for the marked connections, to ensure good regulation. The remaining connections need only be completed with ordinary hookup wire.

Suitable legends can be applied to the front panel using stick-on lettering, pro-

ABOVE RIGHT: Use this wiring diagram as an aid to the placement of components, and then to complete the wiring.

BELOW: The complete circuit diagram. The diode shown dotted gives full overload protection; see text for details.





NOTE: LEADS DRAWN THUS ▬ MUST BE OF VERY LOW RESISTANCE TO ENSURE GOOD REGULATION

FIG. 2 FULLY PROTECTED 30V/2A POWER SUPPLY

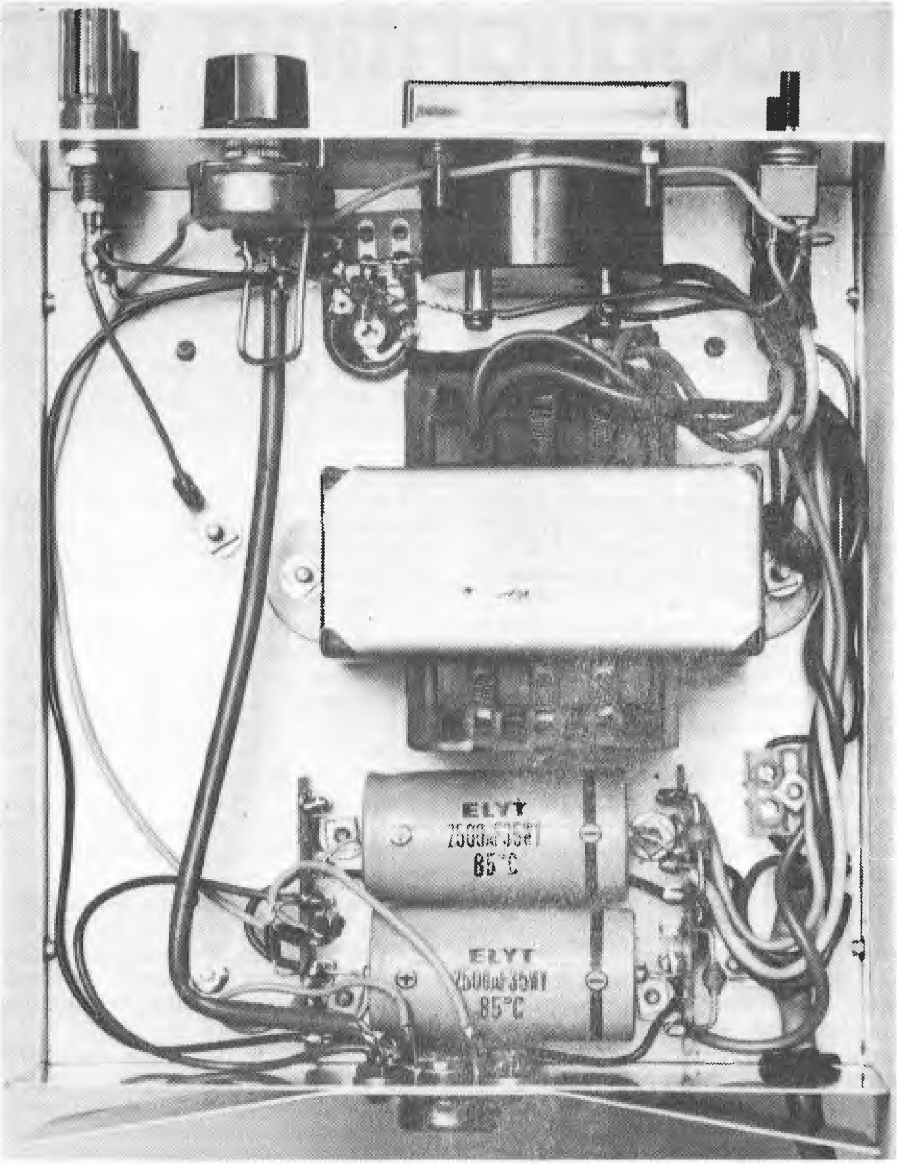
tected by a spraying of clear lacquer. We also rescaled the meter, so that it reads from 0 to 30V and from 0 to 2A. Use a typewriter eraser to remove the original lettering (but not the scale) and re-apply the figures required with stick-on lettering. Once again, protect them with a spraying of clear lacquer.

We found that it was necessary to provide strengthening brackets for the front panel, to prevent excessive flexing. On the right hand side, the connection from the chassis terminal to the chassis was made using heavy gauge wire, which provided sufficient bracing. On the left hand side, a bracket was fashioned (again from heavy duty wire) to fit between the rear of the meter switch and the transformer mounting lug.

Once construction is finished, the unit can be tested, and the current trimpot adjusted. First set the trimpot for maximum resistance, and switch to "volts". With the load switch off, apply power and switch on. Using the voltage control, it should be possible to vary the voltage (as shown on the meter) from about 1.2V to greater than 30V.

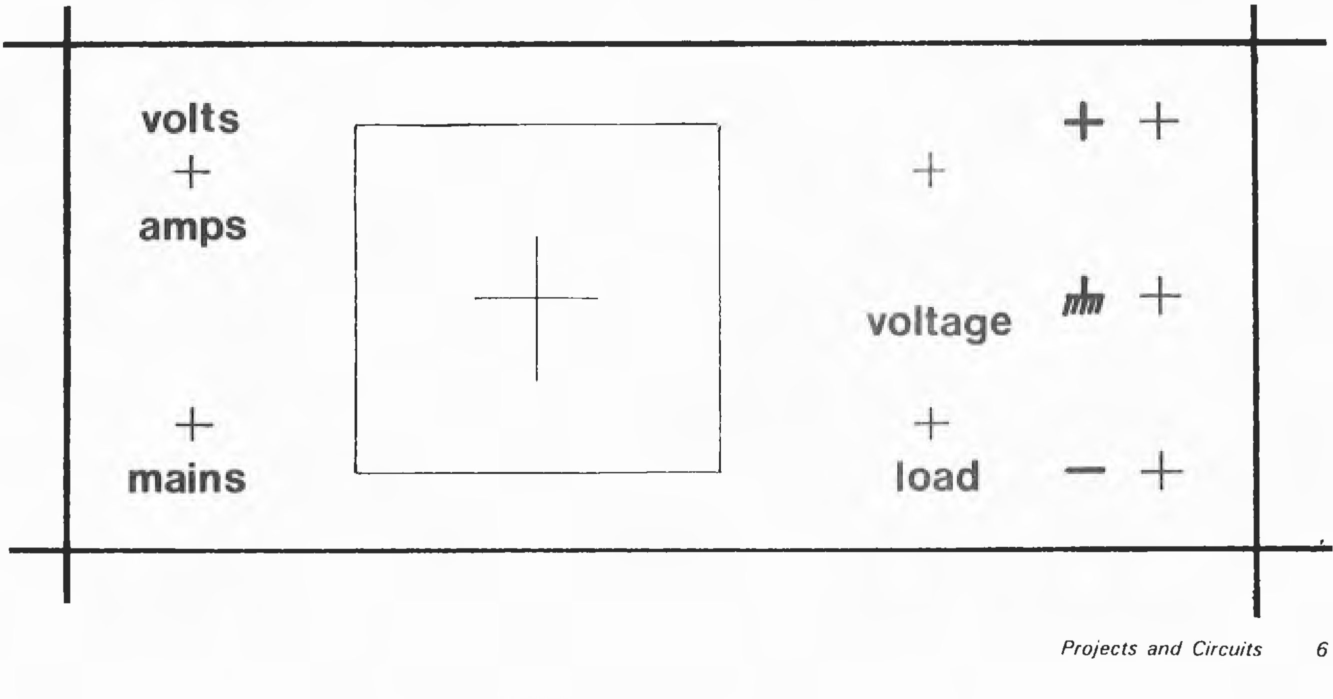
Connect a suitable load resistor (18 ohms at 10W will do) and an ammeter in series across the output terminals. With the voltage set at about 18V, switch on the load. The meter reading should not change appreciably. Now switch to the current range, and adjust the trimpot so that the meter reads the same as the ammeter (about 1A).

If you do not have access to a suitable ammeter, measure your load resistance, and calculate the current flowing through it. Then simply adjust the trimpot to correspond. Note that in use, the heatsink and transformer may rise in temperature to an appreciable extent above ambient. This is normal, and will not cause damage.



ABOVE: Note the two supporting "brackets", one at the left, and one at the right (partially obscured).

BELOW: This full sized replica of the front panel can be used direct, or it may be copied.



Moodlighting with the Varilight Mk 2

Do you still turn on the lights in your dinning room, living room or any other room with a simple on-off switch? You can't vary the brilliance? Now is the time to make yourself a Varilight dimmer.

by LEO SIMPSON

Back in the days of gaslight, people could vary the brightness of their lights at will. Now, in more modern times, it is only recently that we have been able to do the same with electric light. After all, why should you always use the lights at the same brilliance. Bright lights are fine if you'r having a bath, cooking or reading or performing any other activity where the keenest of vision is an advantage.

But there are many times where the maximum brilliance of the lights is not required; such as at parties, dining, watching television, listening to music and other activities which the editor will not permit me to list. There are in fact any number of domestic light dimming applications.

Typical brand name light dimmers often suffer from two problems. The first is a high level of interference to radio reception, which can be very severe in outer metropolitan and rural areas. The second is known as "snap-on" whereby the dimmer control has to be turned through 30 to 40pc of its rotation before the lamp begins to glow. At this initial setting the lamp will be quite bright. The light can be reduced by rotating the control in the opposite direction but at the lower setting a momentary drop in mains voltage may extinguish the lamp.

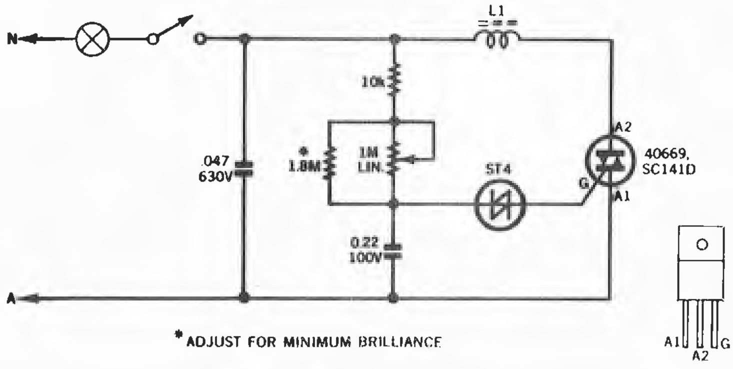
Our Varilight has considerably reduced RF interference and "snap-on" effects compared with most brand name dimmers, and it is more flexible in its application.

A typical light dimmer circuit uses a phase-controlled Triac fired by a symmetrical breakdown device such as a neon lamp, diac or silicon bilateral switch. All of these trigger devices are characterised by a very high impedence in both directions until the voltage across them exceeds a certain value. When this happens the device "breaks over" and becomes a negative resistance.

For a neon lamp, the breakdown voltage is typically in the region of 60 to 80 volts; for a diac, 25 to 40 volts; for an SBS, 6 to 10 volts. The diac is the most commonly used Triac triggering device.

A feature of our new Varilight dimmer is the asymmetrical AC trigger, made by General Electric and designated ST4. It is available in a two-lead TO-98 plastic encapsulation.

This device greatly reduces the snap-on effects that are present in light dimmers using symmetrical trigger devices and single time-constant RC circuits. To explain how it does this let us first look at how "snap-on" occurs in a single RC time-constant Triac/diac circuit as shown in Fig. 1.



*ADJUST FOR MINIMUM BRILLIANCE

L1 = 22 B&S EN CU WIRE CLOSEWOUND ON
2" LENGTH OF 3/8" DIA. FERRITE ROD

VARILIGHT MK. 2

The circuit incorporates an ST4 trigger device and interference suppression.

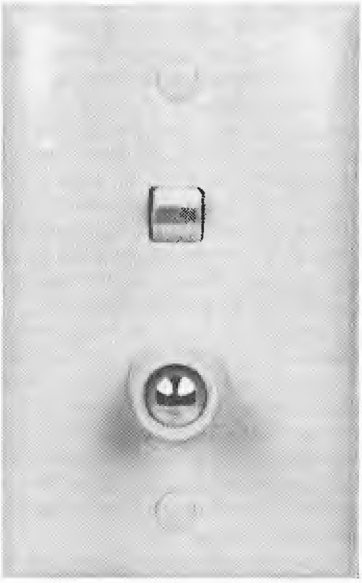


Fig.2 shows two voltage curves, superimposed but not drawn to scale. The large sine waveform represents the 240V mains supply. The smaller waveform shows the voltage across the capacitor in Fig. 1.

Initially, consider the variable resistor set at maximum so that the diac is not firing. In this case, the capacitor voltage is a sine waveform lagging the major waveform. If the variable resistor is reduced in value we will eventually reach the point where the diac fires for the first time, at the end of an AC half-cycle.

Immediately the diac fires the capacitor voltage is reduced from +Vbo by perhaps 8 volts. This means that when the next half-cycle begins, the capacitor will charge to -Vbo sooner than if the diac had not fired. So, the second and succeeding diac trigger points will be sooner than desired.

Thus, the initial level of brilliance obtained when rotating the dimmer control up from zero tends to be relatively high instead of a very low level. Once the diac has begun firing the brilliance can be reduced by winding back the control. But if the mains voltage drops momentarily due to an additional load, the lamp will be extinguished. Inconvenient, to say the least!

This "snap-on" effect can be reduced by adding three components to give a second RC time-constant to the circuit. However the second capacitor is usually a good deal more bulky than the first, due to its higher voltage rating.

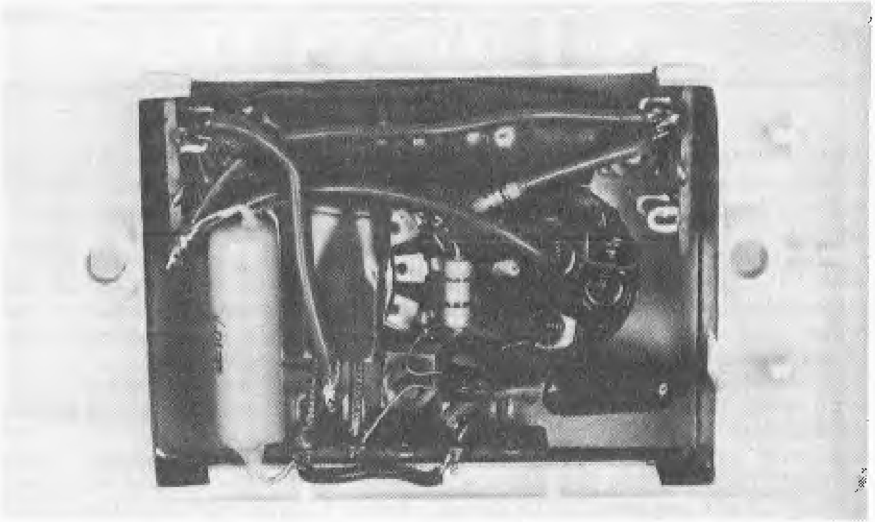
Much the same improvement can be had, without extra components, by using the asymmetrical device, ST4. Typically, this has a breakover voltage, Vs1, in one direction of 16 volts and Vs2, in the other direction of 8 volts. Additionally, its forward voltage (after breakdown) in the Vs1 direction is about 8 volts while that in the Vs2 direction is about 1.5 volts. These latter voltages are referred to as Vf1 and Vf2.

Now consider the circuit in Fig. 1 again but using the ST4 instead of a diac. Now, when the variable resistor is reduced to the point where the ST4 initially fires, the "breakover" is from Vs2 (the lower breakover voltage) to Vf2, as shown at the first trigger point in Fig. 3. But now instead of charging an equal amount in the opposite direction in the next half-cycle, the capacitor must charge to a higher voltage, Vs1, before the ST4 will fire. This means that the firing point in the first two half-cycles is roughly the same. (The ST4 will always fire initially at the lower breakover voltage.)

On the second firing of ST4, the capacitor voltage is discharged to Vf1 instead of Vf2 so that when it is charged to Vs2 it undergoes the same voltage change as it did in the proceeding half-cycle. This means that the firing point in the third half-cycle is the same as it was in the first half-cycle. This train of events is continuously repeated with the capacitor diac voltages alternately shifting to maintain,the same firing point in each half cycle. Thus, "snap-on" is greatly reduced.

The astute reader will no doubt comment: aha! surely the fact that the ST4 has an asymmetrical breakover voltage will mean that the Triac will deliver uneven amounts of power to the lamp during each half-cycle and this will cause visible flicker! And he is right. There is noticeable flicker at low settings with low power lamps, but it is not nearly as pronounced as when half-wave rectified AC is applied to an incandescent lamp. At high power levels, the ST4 still fires unevenly but the effect is so small that it is undetectable.

Refer now to the complete circuit diagram. The 1M potentiometer connected as a variable resistor and the 0.22uF capacitor form the basic RC time-constant circuit. The 1.8M resistor in parallel with the potentiometer sets the minimum brilliance of the lamp(s) when the dimmer control is fully anticlockwise. It eliminates the "dead band" of rotation before the lamp initially lights, and ensures that when the dimmer is switched on there is always some light in the room.



Above is a rear view of the dimmer assembled on a Clipsal switchplate.

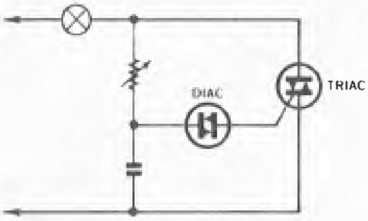


FIG 1

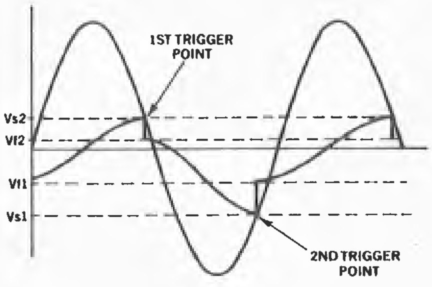


FIG 3

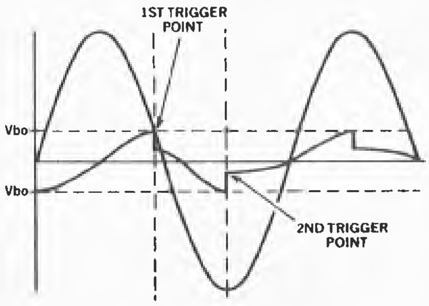
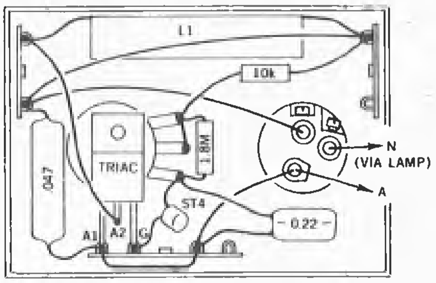


FIG 2



At bottom right is the wiring diagram for the Varilight dimmer. Be sure to check your wiring against the circuit diagram.

The 10k resistor in series with the potentiometer protects the potentiometer track from excessive dissipation when it is set for high levels of brilliance. It also provides current limiting for the ST4 under the same conditions.

L1 and the 0.047uF capacitor remain to be discussed. These form a simple low-pass LC filter which prevents the switching transients of the Triac being radiated by the mains supply leads. As such, it considerably reduces the amount of RF interference produced. Similar RF interference supression components should really be considered mandatory in all phase controlled Triac circuits.

Two types of Triac are specified, both similar in appearance. They are the SC141D made by General Electric and the 40669 made by RCA. Both are encapsulated in a three-lead plastic package with a heatsink tab to which the A2 electrode is electrically connected. In other words, the tab is at mains potential.

Both are rated at 400 volts peak in either direction. RMS current rating is 6A for the SC141D and 8A for the 40669 but both current ratings are considerably higher than our application requires.

Other electrically equivalent Triacs may certainly be used but the advantage of the two specified is that they can be soldered directly into circuit. As such, they can be used with incandescent lamp loads up to 300 watts without any external heatsink. Higher loads may be handled, up to a maximum of 1000 watts if the Triac is mounted on an

Moodlighting with the Varilight Mk 2

adequate (and well insulated) heatsink.

Incidentally the circuit is quite unsuitable for use with fluorescent lights. Do not try it!

The potentiometer is a standard type with a linear resistance/rotation characteristic. Do not use logarithmic types; they do not give progressive control. We have not used a miniature potentiometer as their voltage ratings from terminals to case are not as high as standard types. Typical rating for standard types is 1000VAC (for 1 minute). The charging capacitor is a 0.22uF/100VW polyester or metallised polyester type. Do not use other capacitance values as the circuit has been optimised for this value. The resistors may be ¼ or ½ watt types.

L1, the interference suppression inductor, is not available commercially but is quite easily made. Start by winding a layer or two of plastic insulation tape on a 2in length of ⅜in diameter ferrite rod. If a full length rod has been purchased it can be cut by filing a groove around the circumference and then snapping it as if it was glass.

Close wind a layer of 22 B & S enamelled copper wire over the insulation tape. Then wind insulation tape tightly over the rod in a couple of layers. This last step is important — if it is not wound tightly it will emit a buzzing sound due to the currents being switched by the Triac.

Do not forget to clean the inductor leads of enamel and tin them with solder to make connection into circuit easy.

In outlying areas where the interference produced by the Varilight is still a nuisance, it can be further reduced by enclosing the inductor L1 and the rest of the circuit in a metal box, to stop L1 from radiating.

We constructed our Varilight on a standard dual switch fitting made by Clipsal. One of the switches was removed to accommodate the dimmer potentiometer. The Clipsal switch plate has the advantage that it may be used vertically or horizontally, the switch insert being set for either mode by removing it from the plate and reinserting as desired.

A small chassis is made from 24 gauge aluminium or tinplate and attached to the switch plate to accommodate the circuit components. All the dimensions are shown in the accompanying diagram. They should be closely followed if the unit is to fit a standard power point cavity. Notice the small notch cut in one end of the chassis to allow screwdriver access to the switch terminals.

Order of assembly is as follows. After cutting the potentiometer shaft to a length of ½inch, mount it using two lockwashers, one on either side of the chassis. It is important that it must not be moveable! Then install the three tagstrips, using lockwashers again. All the components with the exception of the Triac should now be installed. If the leads are likely to short against some other component, they should be sleeved with nylex or varnished cambric "spaghetti" sleeving.

Note that the ST4 trigger device may be installed either way around; polarity is non-critical.

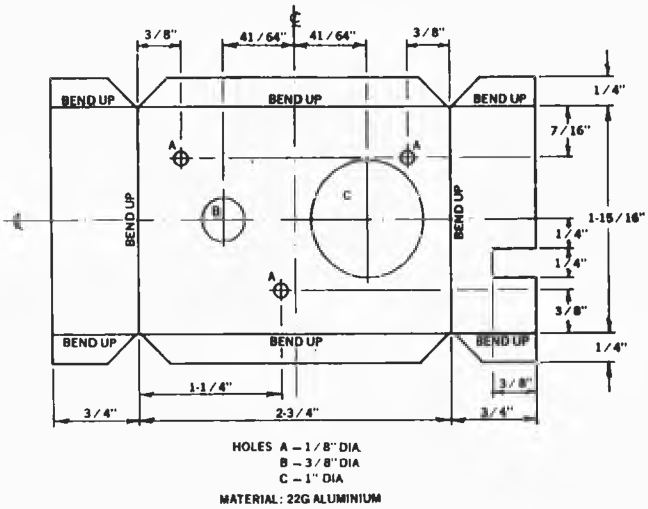
Wrap a few turns of plastic insulation tape around the body of the Triac to prevent it shorting to the potentiometer case. Cut the A2 lead short and bend it up carefully with pliers. Sleeve all the leads and solder into circuit, as shown in the diagram.

Finally, attach the chassis to the switch plate with an epoxy resin glue, taking care to position it exactly. Leave for the required setting time and then attach the knob.

A plastic knob should be used so that the metal chassis and the potentiometer case are isolated from the user. The knob should be installed so its skirt is almost flush with the surface of the switch plate.

Having checked the wiring against the circuit and wiring diagrams, final testing and adjustment may be carried out. Ensure that the switch is assembled so that it functions as single-pole, single-throw type with a "looping" terminal, isolated from the switch terminals. This can be verified with the aid of a multimeter switched to the ohms range. It is also shown in the assembly details supplied with the switch plate.

Testing may be carried out by wiring the Varilight to a three-pin mains plug and connecting a light socket in series with the active lead, as shown in the circuit diagram. With the unit switched both on and off check that there is no voltage between the chassis and the earth pin of the three-pin plug. This is most important.



The chassis is made of light gauge metal and attached with epoxy resin to the switch plate after assembly.

PARTS LIST

1 Clipsal dual switch plate or equivalent
1 power point surround (if required)
1 chassis (see diagram)
1 1M (1in) potentiometer
1 plastic knob
1 Triac, SC141D or 40669
1 ST4 asymmetrical trigger
2 3-lug tagstrips
1 5-lug tagstrip
1 0.22/100VW polyester capacitor
1 0.047/630VW polyester capacitor
1 10k ½ or ¼ watt resisitor
1 1.8M ½ or ¼ watt resistor

MISCELLANEOUS

Hook-up wire, spaghetti sleeving, screws, nuts, lockwashers, insulation tape, 22B & S enamelled copper wire, ferrite rod, epoxy resin adhesive, solder, etc.

The test lamp may be the same as that to be used, although this is not critical. The brightness should increase smoothly with clockwise rotation of the knob. If necessary, replace the 1.8M resistor with another value to give the desired minimum level of brilliance with the lamp load to be used. If zero brilliance is required at minimum setting of the pot, delete the 1.8M resistor altogether.

Since it is a mains operated device, it may be necessary to seek the assistance of a qualified electrician to install it. In any case, the appropriate light fuse must be removed and/or the main switch turned off before any work is done on the lighting circuit. When this is done the Varilight may be installed by connecting the wires from the light switch which it is used to replace.

Remember the maximum load is 300 watts total and that fluorescent lamps must not be used.

New, Universal Headphone Unit

Does your amplifier have facilities for headphone listening? For two people? With main speakers on or off? If your answer is no to any of these questions then this new headphone adaptor may be just the device you're looking for.

by N. J. MARKS & W. N. WILLIAMS

As will be apparent from the accompanying photograph, the headphone adaptor is compact, with a pleasing appearance, and can be placed if necessary on an open shelf alongside other items of hi-fi equipment.

It is "universal" in the sense that it can be used with virtually any amplifier and it will accommodate two pairs of headphones, which can be of dissimilar type.

The internal circuitry is so arranged that the level of one pair can be preset, relative to the loudspeaker volume. This semi-fixed channel could also be used with phones having their own in-built level controls.

Volume from the other outlet can be controlled conveniently by front panel knobs to meet varying needs. It can be adjusted, if necessary, to cope with the needs of a listener who is hard of hearing and / or afflicted with an imbalance of hearing acuity.

Because of these special facilities, the adaptor may, in fact, find a use with many amplifiers having an in-built but more limited headphone facility.

When considering headphones, it is appropriate to stress that modern, high fidelity headphones exhibit lower distortion and a response that is much wider and smoother than the older, general purpose types. Reproduction, overall, compares very favourably with that from high fidelity loudspeakers; this, in terms of available listening level, clarity of reproduction, frequency response, etc. Subjectively, however, there is a difference in the apparent distribution of the sound, when using headphones.

On fully dispersed stereo program material, the listener has the sensation of sitting within the orchestra, with most of the instruments dispersed on either side.

With the more gimmicky "two-channel" type of stereo recording, the listener has the impression of sitting between two distinct groups of musicians. With a "three-channel" type of recording, there is an additional group inside his head!

These impressions are not present when listening to a normal stereo loudspeaker set-up. The sound sources are usually in front of the listener, not adjacent to his ears. Each ear hears each sound source, both by direct and reflection paths, and the listening situation more closely approaches that which it would obtain if the performers were actually located at the far end of the listening room.

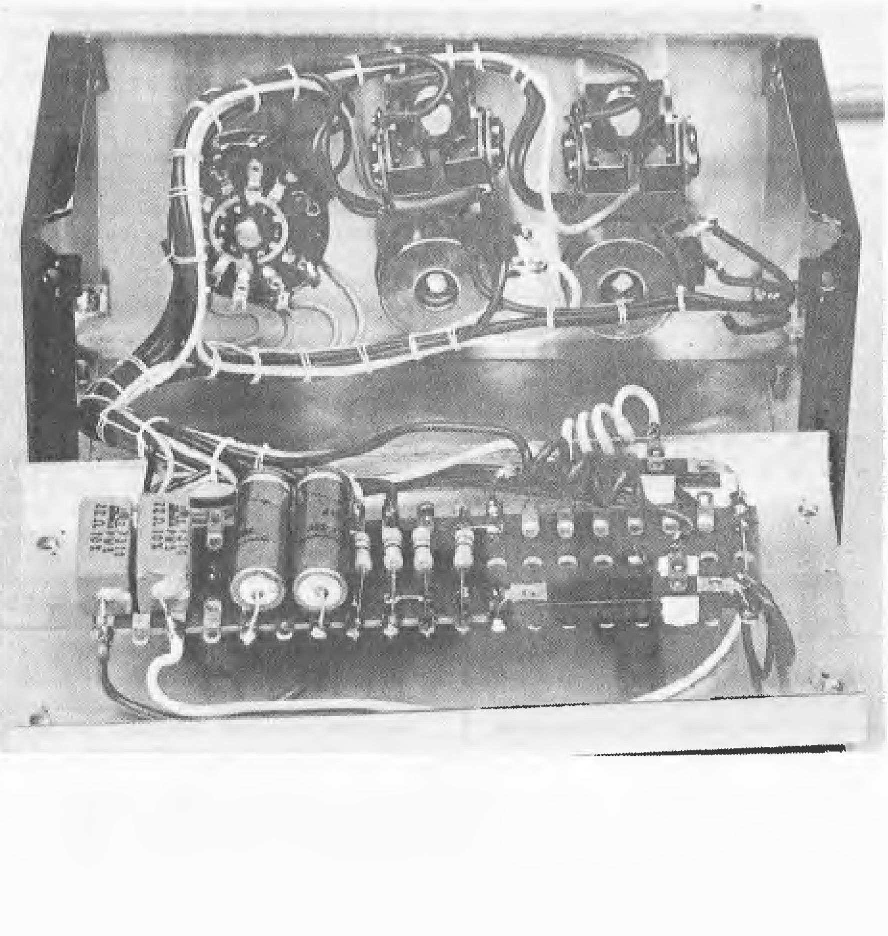
Because of the different illusions created, it is possible to argue that headphones are not a legitimate method of listening to ordinary program material. Be that as it may, however, the reproduction can be very satisfying and an alternative far to be preferred to no listening at all! In fact, headphones have advantages of their own.

They do not suffer from apparent attenuation of the high frequencies due to "beaming" effects as do loudspeakers, since the headphone aims right into the ear, as it were. At low frequencies, provided the phones are adequately sealed to the head by flexible surrounds, headphones can produce plenty of undistorted bass; they do not have to set up a large wavefront in a room and cannot excite boomy room resonances.

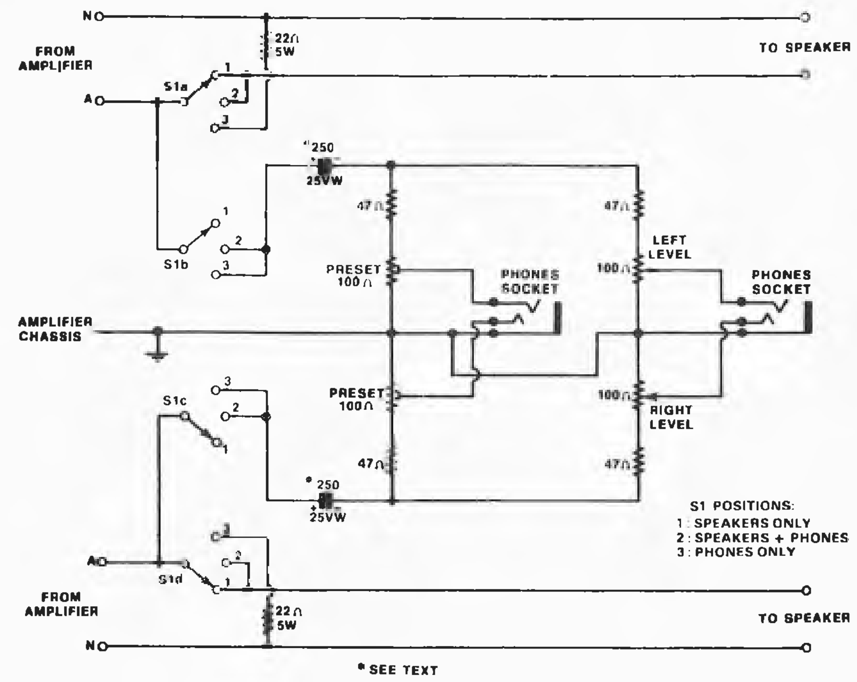
These arguments aside, the real reason for the increasing popularity of headphones is that they enable one to listen to music at any time of the day or night, without restriction to the listening level and without disturbing neighbours, babies or parents.

In designing a universal headphone adaptor, a number of matters have to be considered relating to the drive requirements of headphones and the load conditions presented to the amplifier.

Depending on impedance relationships, headphones clamped to the ears are ef-

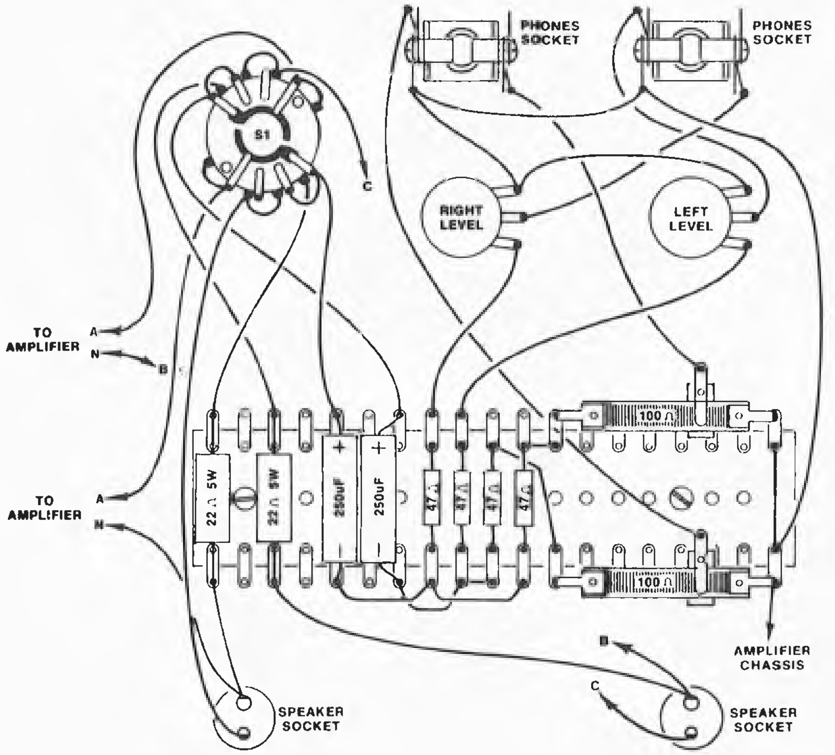


As will be apparent from the picture at the top of the page, the new universal headphone adaptor can be used as a freestanding unit, alongside other equipment. Internally, the use of a tagboard and laced wiring can give it a professional appearance.



UNIVERSAL HEADPHONE ADAPTOR 1/MS/10

Wired as shown in the circuit, the unit retains complete independence of the two loudspeaker output circuits in the straight-through "loudspeaker only" function. By using a blocking capacitor in the headphone feed line and taking the return back to chassis by a fifth lead, a DC parth is avoided between the output circuits. In the "headphones only" position, a 22-ohm resistor provides loading and a DC path in lieu of the loudspeaker voice coil.



For those who want to make a close copy of the prototype, this wiring diagram should provide all the necessary information. In fact, the layout is not critical and the unit could be constructed inside any convenient housing, metal or non metal. See text regarding the coupling capacitors.

fectively much more sensitive than any kind of loudspeaker system standing several feet away. This leads to complications which are likely to inhibit the connection of headphones directly to the output stage in lieu of loudspeakers.

The first arises from the fact that practical amplifiers have some inherent noise and hum output, even with the volume control turned right down. Through a loudspeaker system this is normally not troublesome but, heard through earphones, it is often quite objectionable and sufficient to compromise enjoyment of the program.

Another aspect is that since so little audio power is necessary to produce adequate output from the headphones, the volume control may have to be set at a critical position, not far advanced from fully off. If, by chance, it happens to be turned up too far, the headphones could easily be damaged.

A possible secondary effect is that, at such low volume control settings, the balance between the respective sections of the volume control may be anything but good.

The answer to these problems is the provision in the adaptor of an attenuation circuit (or "pad") such that only portion of the voltage at the output of the amplifier can reach the headphones. It will reduce the hum and noise fed to the phones and allow the amplifier to be operated with the volume control somewhere near the setting normally employed for loudspeaker listening.

Such a pad should be so designed that it will work with any type of headphone, irrespective of the impedance. In practice, impedance ratings may range from a few ohms to a few hundred ohms.

One very suitable arrangement is to connect a 47-ohm fixed resistor and a 100-ohm slider or potentiometer in series across each amplifier output circuit. The phones are connected between one end of the slider (or potentiometer) and the adjustable tapping: this ensures a full range of level control in the phones, relative to the amplifier setting, without danger of adversely loading the amplifier's output circuit.

If it is desired to provide for two pairs of headphones the network in each channel is simply duplicated.

The adaptor unit described here provides the appropriate networks, together with switching to connect the headphones to the amplifier, or the loudspeakers, or headphones and loudspeakers simultaneously.

On its own, a headphone network of this type provides only light loading. While most high quality amplifiers are tolerant of this condition, there may be the odd one which will not be so.

For the above reasons a 22-ohm, 5-watt resistor has been included as a dummy load for each channel; this is brought into circuit when the adaptor is switched to headphone only. The value is low enough to ensure correct operation of all amplifiers likely to be encountered and is high enough for the 5-watt rating to be adequate for likely levels of operation.

In normal stereo systems, the loudspeakers are independent units, each fed by a separate twin lead. Internally, the output circuits of the two amplifiers may be independent of each other in respect to both the active and neutral wiring. It is wise to preserve this isolation, at least in respect to the loudspeakers, to minimise the risk of introducing unforeseen complications.

The need to preserve isolation can be a problem with many types of headphones because they use a common return (or neutral) lead. For this reason a 5-wire circuit has been suggested between the amplifier and headphone adaptor. Four wires maintain the separate active and neutral leads for loudspeaker operation; the fifth wire allows the headphones to derive their drive from between the respective actives and chassis.

One further complication which needs to be provided for has to do with amplifiers which operate with the loudspeaker circuitry above chassis potential: ie neither side of the loudspeaker is returned to chassis earth.

While it may be possible to check on each amplifier with a voltmeter, or by inspecting the circuit, we have provided for the eventuality by including 250uF / 25VW electrolytic capacitors in series with each active headphone feed line. This will prevent the headphones and their related volume controls from providing a DC path between the amplifier active outputs and chassis.

Note that if the DC potential of the voice coil proves to be negative with respect to the chassis, the polarity of the electrolytic capacitors in the adaptor unit would have to be the reverse of that shown in the circuit and wiring diagrams.

To make the adaptor truly universal, the isolating capacitors could be replaced by a bipolar configuration derived by connecting two 500 ufd 25VW electrolytics in series opposition ie with the positive leads connected together and the negative leads taken to the rest of the circuit. On the other hand, if you are absolutely sure that the capacitors are not needed with your amplifier, they can be omitted.

While it would be possible to use a diecast metal box to house the components, for this version we adopted a more stylish approach by using a small instrument case, comprising mainly aluminium extrusions and pressings.

The case is a "Horwood" H43 / 6, approximately 100mm deep, 75mm high and 150mm wide. This case has the advantage of being composed of separate panels, screwed together, which makes for easier work on drilling holes, painting and final assembly. Other styles of case could well suggest themselves to the home constructor. The circuitry could even be built into an existing amplifier, providing panel space is available for the knobs and headphone jacks.

Smaller components were mounted on a 19-lug segment of tag-strip which was spaced off the rear panel by two brass spacers approximately 2cm long, tapped ⅛ Whitworth. Two of the screws holding the loudspeaker sockets are used to mount the spacers which were covered with a length of insulating sleeving to prevent any accidental shorting to the speaker socket connections.

We used McMurdo 2-pin plugs and sockets on the prototype but if your amplifier uses a different type of plug or means of connection, it might be logical to duplicate them on the adaptor.

The two preset sliders are mounted at one end of the tagstrip followed by the 47-ohm dropping resistors, the 250uF isolating capacitors and the 22-ohm dummy load resistors.

The cable used to connect the adaptor to the amplifier should most obviously be a five-core type. Alternately various types of four-core cables with some cores shielded might be more readily available; the braids could be used as the common return to chassis for the headphones.

Terminations are protected by clamping the cable where it enters the case through a grommetted hole. The two neutral leads for the speakers are taken direct to the sockets on the back of the case; the active leads go to the switch.

Once you have completed the adaptor, you can connect it to your amplifier and check for correct polarity of the active and neutral leads.

On those amplifiers with screw terminals for the loudspeaker connections, the active side may be coloured red or coded with a "plus" sign. If this is not the case, the active side of the speaker output may be determined by trial and error when the adaptor is completed; if the headphones are effectively connected between neutral side of the amplifier output and the amplifier chassis, no sound will be heard.

When everything is properly connected, turn the front panel potentiometers and the sliders to their minimum position.

Put a record on the player and with the switch in the "speakers only" position, adjust the volume to the average listening level.

Switch to the phones only position and adjust the sliders to give you a satisfactory level with the phones in the appropriate socket and repeat this performance with the front panel controls and their socket. In this way you won't need to leap for the volume control when you plug in the 'phones for some personal listening.

You won't hear any noticeable difference in speaker output when the selector switch is in the "Speakers plus phones" position, due to the minimal loading of the attenuator network.

Incidentally, if you make up an extension cord using a stereo phone plug and socket, and a length of three-core cable, sound can be conveyed to somebody confined to bed, so that they can enjoy the music along with other members of the family, or alone.

PARTS LIST

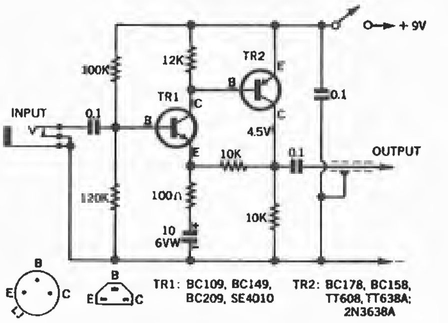
- 1 Horwood H / 43 / 6 case
- 1 4-pole 3-position switch. Oak 52259 or similar
- 2 Stereo jack sockets
- 1 19-lug piece of component strip
- 2 Speaker plugs and sockets
- 2 250uF / 12VW Electrolytic capacitors (see text)
- 4 47-ohm ½-watt resistors
- 2 22-ohm 5-watt resistors
- 2 100-ohm slider resistors
- 2 100-ohm wire-wound potentiometers
- 3 knobs, 5-conductor cable or 4-conductor with shield, cord clamp, hook-up wire
- 2 brass spacers tapped ½ Whit 2cms long screws, nuts etc.

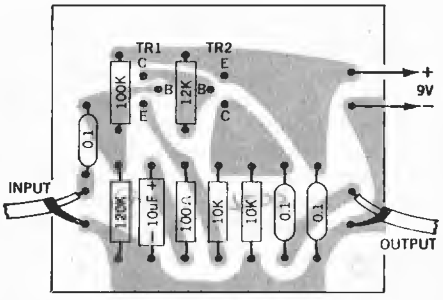
A Microphone Preamplifier

This handy microphone preamplifier circuit can be built on a printed board (no. 72/p2) measuring 64 x 54mm. It has a voltage gain of 100 and draws only 0.45mA at 9V, which can be supplied from a small battery. Alternatively, supply can be obtained from a convenient positive point in the associated amplifier, through a dropping resistor. To calculate the value of same, divide the necessary voltage drop by 0.45 and multiply by 1000; or simply multiply the required voltage drop by 2200 and call the answer ohms.

If supplied through a dropping resistor, the 0.1uf capacitor should be replaced by an electrolytic bypass of 50uF or more at a working voltage of 12VW or more.

A conventional circuit configuration is used. An NPN and PNP silicon transistor are connected together in a direct-coupled feedback-pair arrangement with both transistors operating as common-emitter amplifiers. Negative AC DC feedback is applied from the collector of the PNP transistor, Tr2, to the emitter of the NPN transistor, TR1, via a 10K resistor. The ratio of the 10K resistor to the 100 ohm resistor in the emitter circuit of TR1 sets the voltage gain of the circuit to 100.


+ 9V
100K
12K
TR2
E
B
C
0.1
TR1
C
INPUT
0.1
B
4.5V
E
10K
0.1
OUTPUT
120K
100Ω
10K
10
6VW
B
E
C
B
E
C
TR1: BC109, BC149, BC209, SE4010
TR2: BC178, BC158, TT608, TT638A; 2N3638A



Input impedance of the circuit is close to 50K, set by the parallel combination (to the input signal) of the bias resistors for Tr1. As such, it is suitable for dynamic microphones requiring a load of 50K. It can also be used to follow low output impedance FET preamplifiers for condenser microphones.

Physically, the preamplifier should be mounted inside a metal box connected to the negative supply line to combat hum and penetration of radio and TV signals. The microphone input lead should be the shielded type, as also the connection to the main amplifier.

If the bass response of the microphone circuit is too prominent with close speech, the 10uF capacitor can be reduced in value, as necessary.

There is no need to unsolder suspect transistors!

Build an In-Circuit Transistor Tester

Servicing solid-state equipment can present problems because of the difficulty in checking components without removing them from circuit. An "in-circuit" transistor tester can be a great help in this regard as it can pinpoint most malfunctioning transistors. Servicemen and hobbyists are sure to find the simple tester presented here a most useful aid.

by LEO SIMPSON

This device was originally published in the English magazine "Television" in October 1976. Their version was assembled on Veroboard and housed in a diecast case. Our version is assembled on a PC board and housed in a low-cost plastic case. In other respects, the design is virtually identical.

Until recently, in-circuit transistor testers have not been readily available nor cheap to buy in Australia. So servicemen and hobbyists have had to rely on voltage measurements to locate faulty transistors. Even so, there are many circuit applications where voltage measurements may not give a clear indication of faulty devices. Flip-flops are just one example.

Another reason why voltage measurements may not be useful is that power applied to a faulty circuit may cause further damage. And while ohmmeter measurements can be helpful, they do not always give clear cut results.

So a strong case can be made for an in-circuit transistor tester of the type described here. Indeed, we suspect that once a serviceman or hobbyist has used such a device he may wonder how he ever managed without it.

Both NPN and PNP transistors can be tested without operating switches or controls.

There are two LED indicators. When a good NPN device is tested, one LED flashes. If a good PNP device is tested, the other LED flashes. If the device is faulty, either both LEDs flash or both are extinguished.

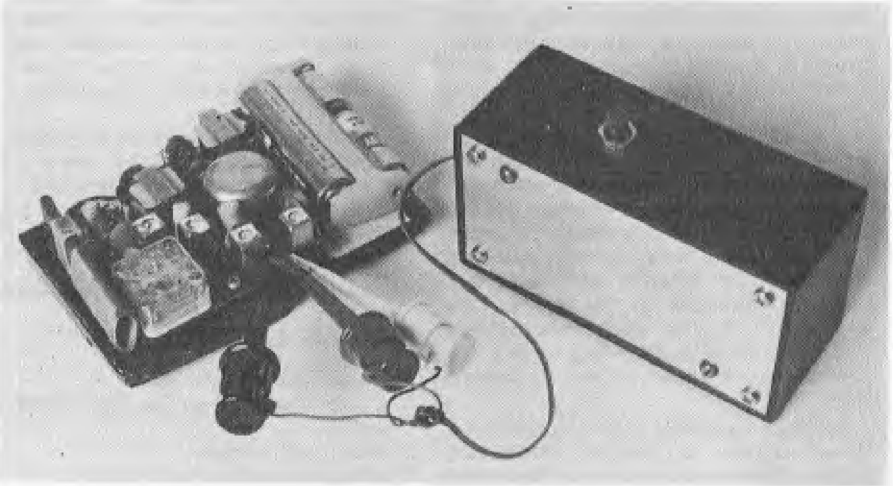
All that the tester is supposed to indicate is that transistor action is taking place—i.e., base current causes the collector-emitter path to become a low resistance in one direction. The tester does not give any indication of beta or high leakage in a transistor.

The nucleus of the circuit is a 555 timer integrated circuit working in the astable mode. It produces a square wave at pin 3 with a duty cycle of approximately 50% and a frequency of about 3 hertz.

The square wave output from pin 3 of the 555 is fed to the bases of a pair of complementary transistors with their collectors tied together. The transistors produce an inverted version of the square wave input. So the circuit described this far is a low frequency generator with complementary outputs, which have been designated the X line and the Y line.

The total output derived from the X and Y lines is a square wave with amplitude approximately equal to twice the battery voltage. This 3Hz square wave is applied, via a 330 ohm resistor, to a pair of light emitting diodes connected in inverse parallel. With no transistor under test, this results in the LEDs flashing alternately at the 3Hz rate.

When the transistor under test is a "good" NPN type, it will conduct when line X is positive with respect to line Y. This will extinguish LED 1. LED 2 will continue to flash at the 3Hz rate to indicate "NPN OK".



Checking suspect transistors in a circuit is easy with this In-Circuit Tester.

Similarly, when a good PNP transistor is under test, it will conduct when line Y is positive with respect to line X. This will extinguish LED2 and allow LED1 to flash the "PNP OK" signal.

Any transistor under test with an open circuit junction will extinguish neither LED, so both continue to flash. Transistors with a short circuit between collector and emitter will extinguish both LEDs.

The circuit also has to distinguish between functional transistors and those devices with short-circuit collector-base or base-emitter junctions. This is where diodes D1 and D2 come into the picture. The voltage drop across a functional transistor, when conducting, is typically 0.2V or less, in this circuit. By contrast, a device with a short circuit c-b or b-e junction will have a voltage drop of about 0.7V.

Thus, when a functional NPN device is being tested, the forward voltage drop across LED1, due to D1 and the transistor under test, will be small enough to extinguish it. But when a device with a short-circuit junction is tested, its forward voltage drop combined with that of D1 (or D2), is enough to allow the associated LED to continue flashing. So both LEDs continue to flash for a device with a short-circuit junction.

Since the current drain is quite low and the likely use is intermittent, the power requirement can be met by a small 9V battery such as the Eveready 216.

We assembled the circuit on a small PC board measuring 76 x 45mm, code 77tt4. The transistors used may be BC548 and BC558 or any of their multitudinous equivalents. The diodes are 1N4148 or equivalent.

Space has been provided on the PC board for additional diodes in series with D1 and D2. These may have to be added to suit particular LEDs. This is because some LEDs have a wider or narrower voltage range over which they will emit light. So it may be necessary to add more diodes or use a combination of silicon and germanium diodes to obtain satisfactory LED indications. The criteria are: One LED must be extinguished by a functional transistor under test; both LEDs must continue to flash when a transistor with a shorted junction is under test.

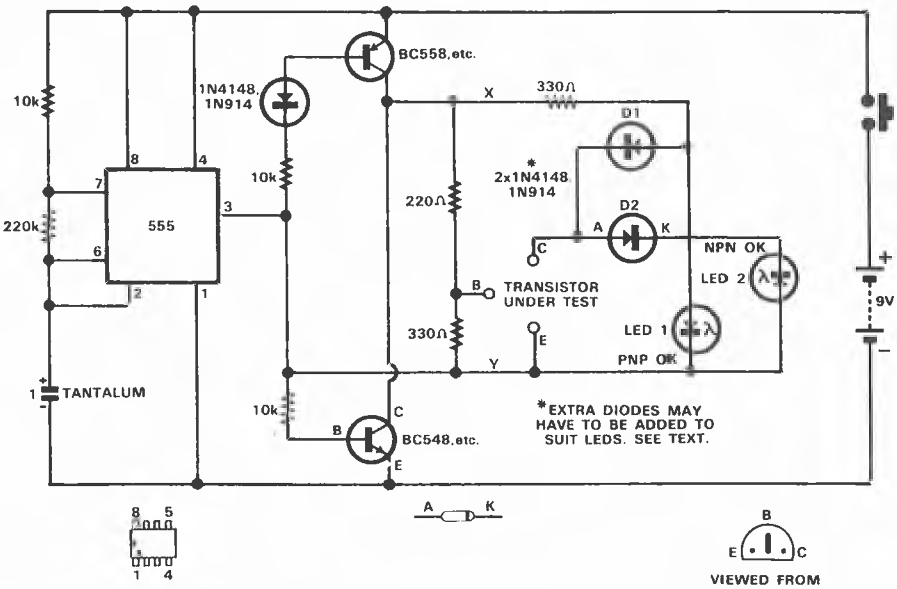
A small plastic box with a light-gauge aluminium lid houses the prototype tester. Measuring 102 x 53 x 41mm, these plastic boxes are available at low cost from Dick Smith Electronics Pty Ltd.

There is no special wiring layout required for the tester. Use a small low powered iron when soldering.

PARTS LIST

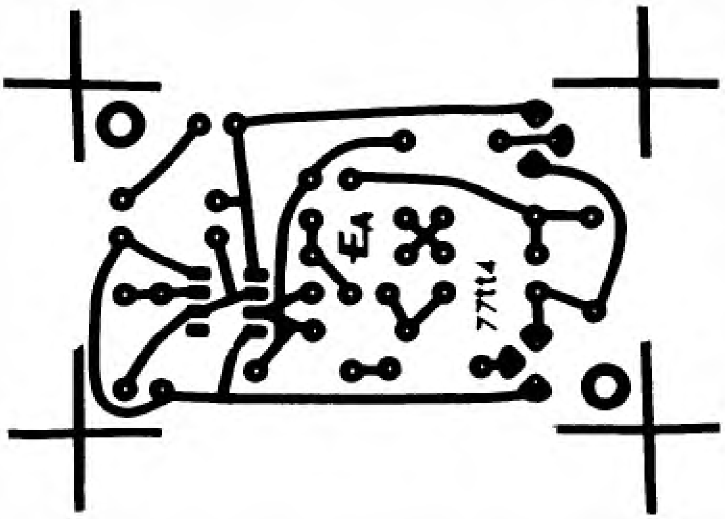
1 plastic box, 102 x 54 x 41mm, with aluminium lid
1 PC board, 76 x 45mm, code 77tt4
1 555 timer integrated circuit
1 BC548 NPN transistor
1 BC558 PNP transistor
3 1N4148 silicon diodes
2 red LEDs
3 small E-Z hooks, red, black, grey
1 9V battery, Eveready 216, plus connector
1 push-button switch with "normally open" contacts
1 1uF tantalum capacitor

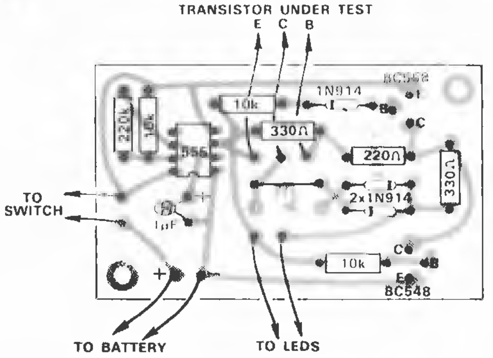
RESISTORS
(½ or ¼W, 10% tolerance)
1 x 220k, 3 x 10k, 2 x 330 ohms, 1 x 220 ohms.
Battery clamp, connecting wire, screws, nuts, washers, solder.



IN-CIRCUIT TRANSISTOR TESTER 7/VT/—

The circuit is basically a 3Hz oscillator with complementary outputs.





Above is the PC pattern, actual size. At left is the component layout.

Two schemes could be used for making connections to transistors in circuit. The method used in "Television" was to have a pair of probes, one containing the circuitry and the other with a double prod. This would work well for testing from the underside of PCBs, but might be inconvenient when testing transistors with the less common leadout arrangements. It would also be less practical when working from the component side of a PCB.

Our method, which is easier to implement, uses three miniature clips of the E-Z hook type. The type we actually used was the Pomona "grabber". In practice though, these are a little large and a smaller type is better suited to crowded PCBs.

We used a red hook for the collector connection, a black hook for the emitter connection (corresponding to positive and negative) and a grey hook for the base connection. This works quite well and is easy to remember.

While our system of E-Z hooks or similar is more practical when working from the component side of a PCB, it may not be usable on the copper side. So readers have to make the decision as to which method is more suitable to their applications. Either way, the in-circuit tester can be a handy device.

In use, the tester will give clear indications where the surrounding circuit resistances are 40 ohms or more. It tends to give ambiguous indications when testing the output stages of audio amplifiers, where the circuit resistances are lower than this.

Automotive project:

A Trafficator Repeater

In this article we present the design and constructional details of a solid state relay unit, intended to drive the indicator lights of trailers and caravans without upsetting the flashrate of the car. It is short circuit proof, and requires a minimum of wiring to be added to the car.

by DAVID EDWARDS

The incentive for this project arose out of the author's experiences with an earlier electromechanical (relay) unit. This unit had the virtues of reliability and simplicity, and gave good service for about two years on a Mini-Moke.

The relays were mounted in a diecast box, along with the standard trailer connector. The relay coils were connected in parallel with the car's indicator lights, with the normally open relay contacts used to switch the trailer indicators. Power for these lights was obtained directly from the battery (via the accessories fuse), and required a single wire to be run from the front to the rear of the car.

The unit was recently transferred to a less "spartan" car, and I was quite surprised to find that it would not operate when the car engine was running. A quick investigation showed the cause of the trouble, and started me on the path leading to this article.

Many modern cars are fitted with warm-up resistors for the trafficator lights, so that they are not switched completely off between flashes. This has a twofold effect: it increases the life of the lamps, by reducing the inrush current, and it prolongs the life of the trafficator unit, by reducing the maximum current which has to be switched.

This means that the voltage across the lamps does not fall completely to zero between flashes, as it did on my previous car. The relays used had a rather low dropout voltage, and with the new car they were remaining energised all the time when the indicators were in use.

Rather than cure this by increasing the dropout voltage, I elected to design a transistorised unit instead. The final circuit is as shown in the diagram. A PNP power transistor is used to switch the lamps on and off, and is controlled by a smaller NPN transistor. The base of this transistor is driven by a resistor/zener diode network connected to the car indicator circuit.

This network ensures that the lamps will remain off for all input voltages less than 6V, and will come on for voltages exceeding 6V. The actual switch action occurs over a very small voltage range, giving a very definite transition between the on and off states.

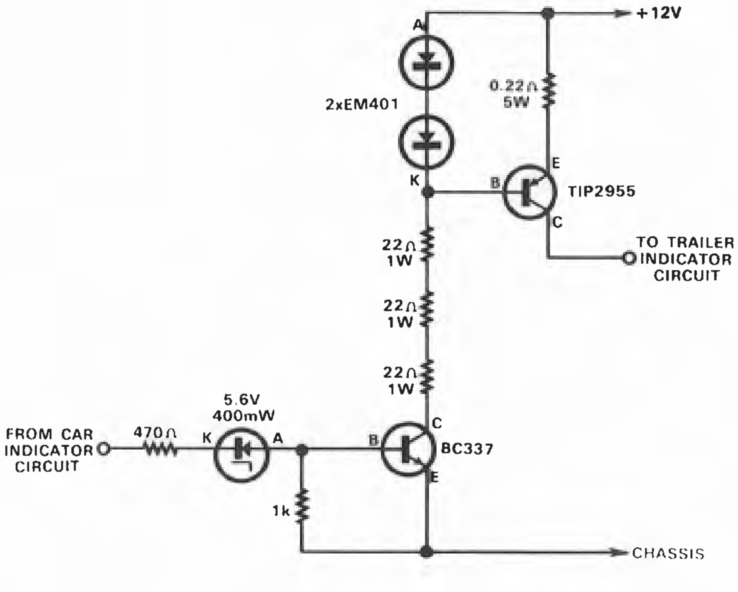
The power transistor is connected as a constant current generator. Two series diodes are used as a voltage reference, and the transistor action tries to keep a constant voltage across the 0.22 ohm current sensing resistor. The value of this resistor has been chosen to provide a collector current of 3A.

The normal indicator bulb is a 12V 21W unit, and draws a current of about 2A. Thus it draws insufficient current from the pass transistor, which therefore remains saturated. The total voltage drop across the transistor and current sensing resistor is then about 1V, so that the lamp brilliance is not reduced significantly.

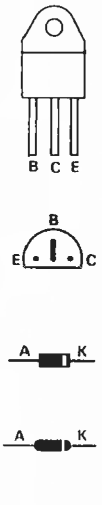
Power dissipation in the pass transistor is thus negligible under normal conditions. If the indicator lamp is short circuited, the current rises, but to the 3A level. The transistor starts to dissipate a significant amount of power, but the device we have specified has a 90 watt rating, which means that with an adequate heatsink, it should be able to withstand a short circuit indefinitely.

A second advantage of the circuit is that any inrush current to the lamp is also limited to 3A. This should act to prolong the life of the bulb.

Actually two of the circuits shown are required, one for each indicator circuit. We have designed a small printed circuit board, coded 77t10, and measuring 66 x 66mm, which has provision for the two circuits. All components mount on the



TRAFFICATOR REPEATER CIRCUIT



3/AU/

This is the circuit diagram of the basic relay. Two of these circuits are required, one for each indicator circuit.

board, although the two power transistors must also be bolted to a suitable heatsink.

We mounted the PCB in a standard diecast box, with the commonly used Utilux trailer connector fitted to the side of the box. A small terminal block is mounted on the outside of the box, as a termination point for the wiring to the car circuits. A number of small grommets are used to lead the wires from the terminal block into the box. The box itself forms the heatsink for the power transistors.

The box is best mounted upside down at some convenient point next to the towbar, with the connector for the trailer socket facing the rear.

Five wires are required to the unit, two for the indicators, one for the tail light, one for the brake light, and the positive supply line. The leads from the indicators connect to the PCB, while the tail and brake light leads connect directly to the trailer socket. The +12V supply lead can be obtained from the boot light circuit, thus avoiding the need to run a cable from the front of the car.

A fuse should be present in this lead, so one must be fitted if the boot light circuit is not already fitted with one. There is no need to switch the supply line with the ignition switch, as when the ignition is off, the current consumption is neligible.

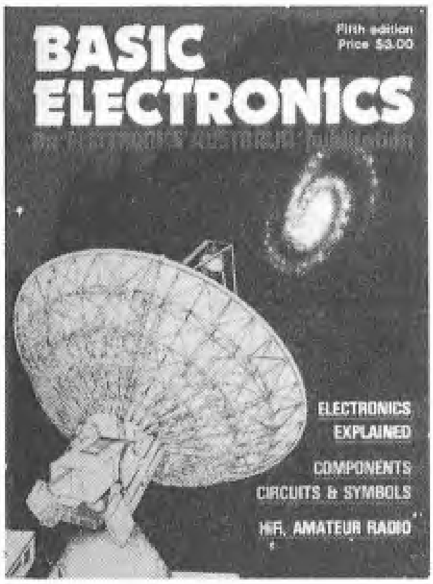
Construction of the unit is very straightforward. The PCB mounts on the bottom of the case, orientated so that the

PARTS LIST

- *2 TIP2955 PNP power transistor (plastic pack)*
- *2 BC337 NPN transistors*
- *4 EM401 silicon diodes*
- *2 5.6V 400mW zener diodes*
- *2 0.22 ohm 5W resistors*
- *6 22 ohm 1W resistors*
- *2 470 ohm ¼W resistors*
- *2 1k ¼W resistors*
- *1 Utilux trailer connector, cat. No. H1115*
- *1 die cast box, 114 x 89 x 51mm or similar*
- *1 printed circuit board, coded 77t10, measuring 66 x 66mm*
- *5 small grommets*
- *1 5-way terminal block*
- *Solder, hook wire, machine screws and nuts, mica washers, heatsink compound, PCB pins, solder lugs.*

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with high ratings may generally be used provided they are physically compatible.

Two basic texts for the electronics enthusiast



BASIC ELECTRONICS

Basic Electronics, now in its fifth edition, is almost certainly the most widely used manual on electronic fundamentals in Australia. It is used by radio clubs, in secondary schools and colleges, and in WIA youth radio clubs. Begins with the electron, introduces and explains components and circuit concepts, and progresses through radio, audio techniques, servicing, test instruments, etc.

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Fundamentals of Solid State is in its second printing, showing how popular it has been. It provides a wealth of information on semiconductor theory and operation, delving much deeper than very elementary works but without the maths and abstract theory which make many of the more specialised texts very heavy going. "Solid State" has also been widely adopted in colleges as recommended reading — but it's not just for the student. It's for anyone who wants to know just a little bit more about the operation of semiconductor devices.

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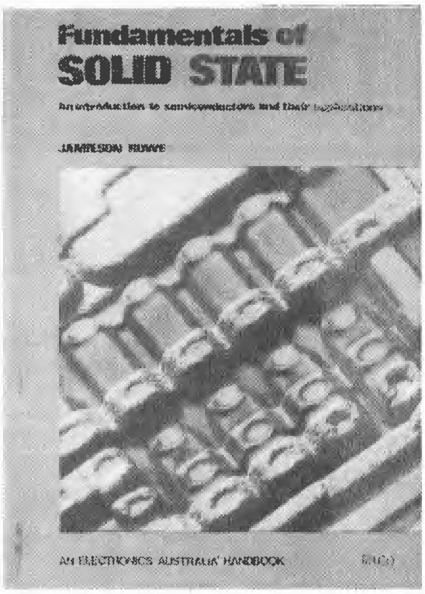
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power transistors can be fastened to the side of the box. They must be insulated from the box, using mica washers, but should be thermally bonded to the case using silicone heatsink compound. It might also be a good idea to use nylon bolts and nuts to bolt them to the case, to make insulation more reliable.

The PCB must be mounted close to the case, to allow clearance for the trailer socket. To prevent accidental short circuits, place a piece of cardboard or similar insulating material underneath the board.

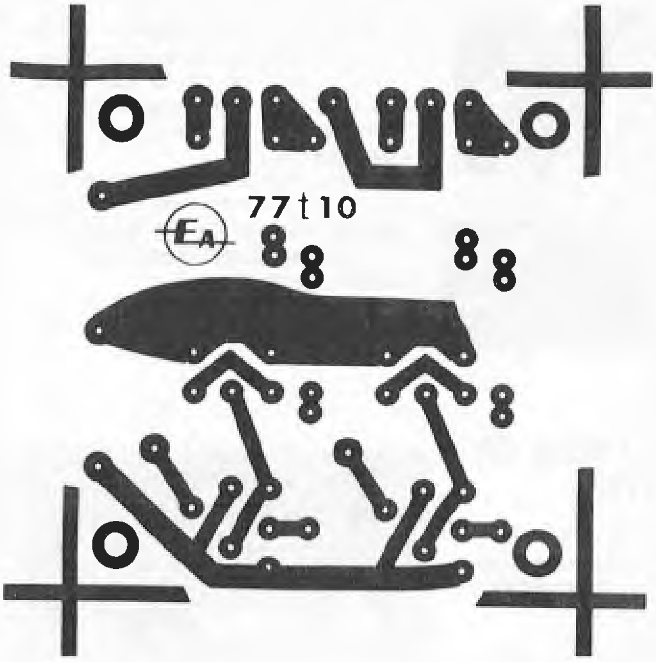
The circuit as drawn is intended for use with negative earth cars. It can be adapted for positive earth cars simply by using opposite polarity transistors. Replace the TIP2955 with a TIP3055, and the BC337 with a BC327. The EM401s and the zener diode will have to be fitted in the reverse polarity to that shown in the PCB overlay diagram.

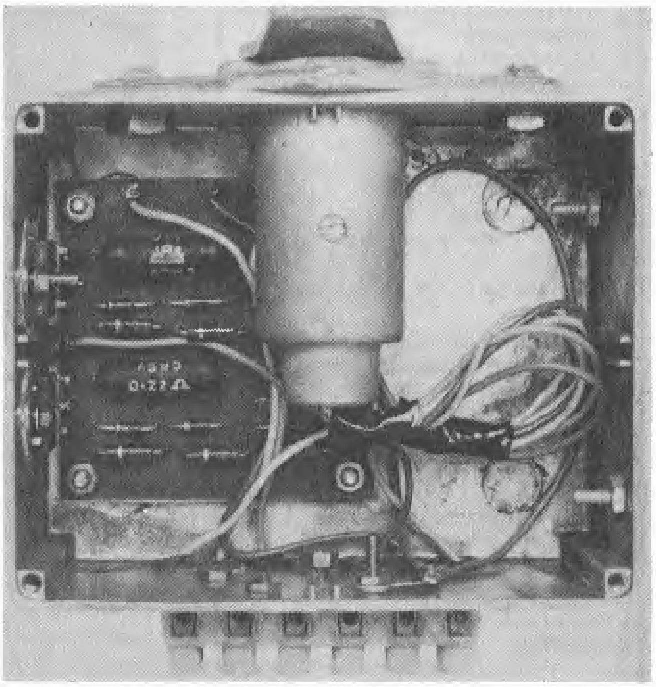
When mounting the 5W and 1W resistors, set them up a little from the board, to allow air circulation for cooling. This will also prevent the PCB from being damaged. We recommend that PCB pins be used to make the connections to the PCB, as these make construction easier.

Wiring details for the Utilux connector are normally supplied with it, and to ensure uniformity they should be followed exactly. The centre pin is the trailer earth return, and it should be reliably connected to the diecast box, which in turn should be earthed solidly to the car chassis. This can normally be accomplished by the mounting screws.

The unit when completed is best tested by actually trying it with a trailer. If a trailer is not available, it can be tested by wiring up an electrical equivalent of a trailer. The tail and brake light circuits can be checked out with a multimeter, while to test the indicator circuits, it will be necessary to use two 12V 21W globes.

Connect the bulbs between the pass transistor collectors and the car chassis, and check that they operate as and when required. If the unit fails to operate correctly, check first for faulty joints, and then for incorrectly oriented transistors. The lead configurations we have shown may not be correct for transistors other than those specified.

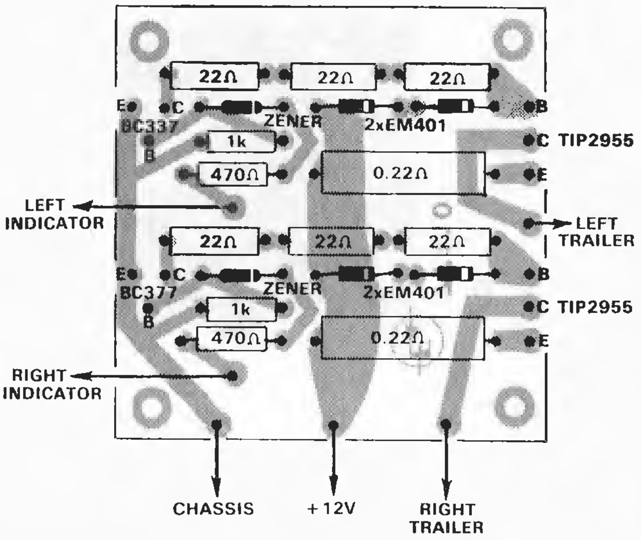


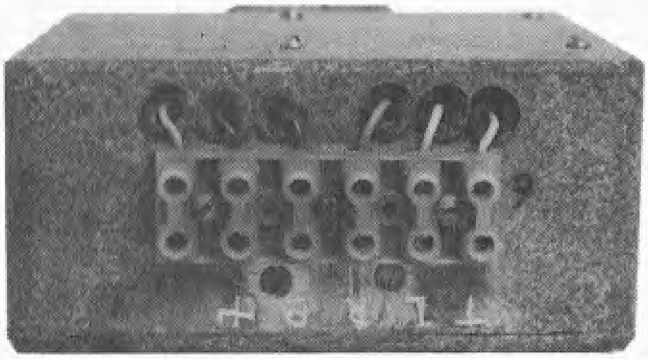


ABOVE LEFT: This full size duplicate of the PCB pattern can be traced if desired.

LEFT: Use this diagram as a guide to the placement of components.

ABOVE & BELOW: Use these photographs to aid in the assembly of the unit.





Short-wave converter for the 27MHz band

. . . simple project for listening to CB radio operators

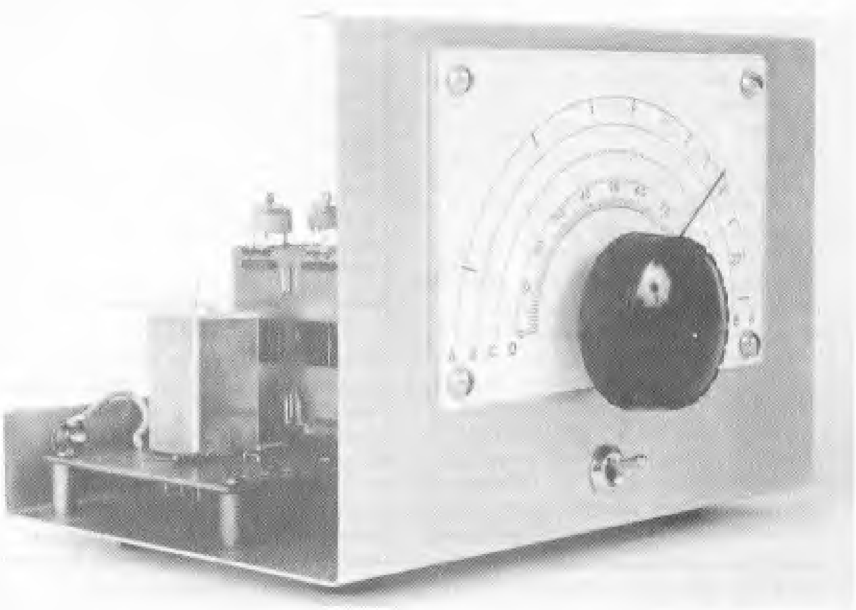
This latest addition to the "Electronics Australia" line of converters is designed to let you listen into CB activity on the 27MHz band. The converter is simple to build, effective, and suitable for use even with personal portable receivers. It can be fed either into a receiver tuned to the broadcast band, or modified to feed into a 3.5MHz short wave receiver.

by IAN POGSON

Beginning in the April 1973 issue of "Electronics Australia", the author described a series of simple converters covering various tuning ranges. Since then interest has grown considerably in the 27MHz band, brought about by the legalisation of CB radio in mid-1977. There are now literally thousands of operators on 27MHz, and the number is increasing daily.

It was this obvious widespread interest in CB radio that prompted the author to add a converter to the series which would specifically tune to 27MHz. The main design objectives called for a unit that would be low in cost and simple to build.

After some thought, it was decided that the original concept should be followed, using the original "universal" PC board. Also, many beginners (and others) would wish to feed such a converter into a personal portable or perhaps a larger transistor domestic type radio, as well as those readers who might want to feed the converter into a short wave receiver which did not tune up to 27MHz. Each of these requirements has been considered and although the circuit as shown is designed to feed into a receiver tuning the broadcast band, details will be given later on showing how it can be fed into a short wave receiver at about 3.5MHz.



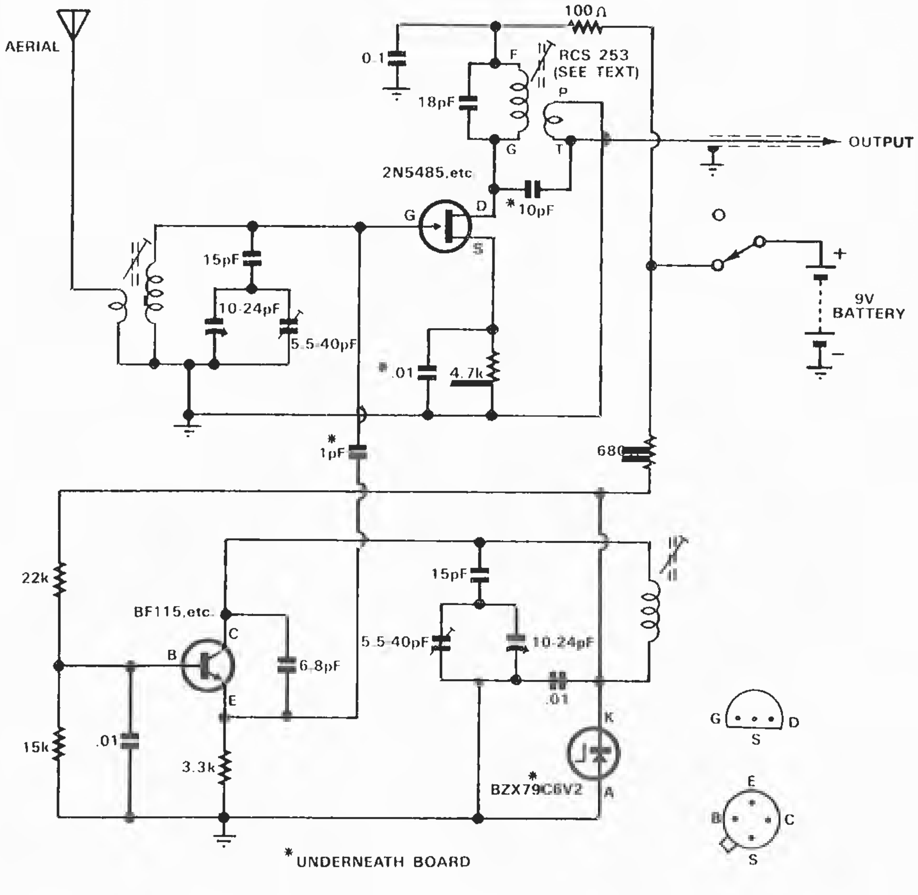
Frontal view of the completed converter, with the aerial coil and tuning gang both visible behind the front panel. A simple, folded aluminium chassis is used.

Perhaps at this early stage it should be pointed out that there are some limitations to feeding the converter into an ordinary broadcast receiver. It means, of course, that you are limited to the amount of selectivity available in the receiver, although generally this should be sufficient. Also, the normal receiver is designed to resolve AM transmissions and will not respond satisfactorily to other modes such as FM and SSB. Fortunately, most of the transmissions at present on the 27MHz band are on AM and so any restrictions here will be minimal.

The circuit is an adaptation of those which have been presented before. It may be seen that it is about as simple as it could be. The mixer is a junction FET, with a tuned circuit at signal frequency in the gate or input circuit. The drain or output of the FET includes another tuned circuit, this time at the first intermediate frequency, to feed into the broadcast receiver. There is a 4.7k resistor in the source of the FET, which may appear to be a rather high value, one which would bias the FET well back into the "knee' or non-linear part of the characteristic curve. This is so, in fact, and is a requirement for efficient mixing of the incoming signal with that from the local oscillator.

The local oscillator itself uses a bipolar transistor, and the circuit is an adaptation of that used for our Solid State Dip Oscillator and many other more recent projects. This oscillator can be made to operate satisfactorily over a very wide frequency range. The tuned circuit consists of a coil winding similar to that used for the signal frequencies, together with the other section of a 2-gang variable capacitor.

It may be seen that there is a 15pF capacitor connected in series with each section of the gang. These are added to restrict the tuning range provided by the



EA 27MHz CONVERTER

PARTS LIST

1 *Chassis-panel, 165mm long x 127mm high x 127mm deep*
1 *Cabinet to suit*
1 *Dial assembly, Jabel 6/36N*
1 *Flexible coupling, ¼in x ¼in, Jabel*
1 *Miniature toggle switch, SPDT*
2 *Terminals, 1 red, 1 black*
2 *Large 3-tag strips (battery supports)*
4 *Rubber feet*
1 *Grommet for coax cable*
6 *Spacers, 12½mm long, tapped ⅛in Whitworth*
1 *Printed board, 152mm x 76mm, 73/3C*
1 *Aerial Coil, RCS type 253*
2 *Neosid coil formers, 7.6mm x 35mm, with grade 900 slug and can*
1 *Zener diode, BZX79C6V2*
1 *Transistor, 2N5485 or similar*
1 *Transistor, BF115 or similar*
1 *9V battery, No. 2362*

RESISTORS (½W)
1 *100 ohms*
1 *680 ohms*
1 *3.3k*
1 *4.7k*
1 *15k*
1 *22k*

CAPACITORS
1 *1pF NPO ceramic*
1 *6.8pF NPO ceramic*
1 *10pF NPO ceramic*
2 *15pF NPO ceramic*
1 *18pF NPO ceramic*
1 *10-24pF Roblan 2-gang variable*
2 *5.5-40pF Philips trimmers*
3 *.01uF 200V greencaps*
1 *0.1uF 100V greencap*

MISCELLANEOUS
Hookup wire, coax cable, solder, scresw, nuts
Note: Resistor wattage ratings and capacitor voltage ratings are those used on the prototype. Components with higher ratings may generally be used providing they are physically compatible. Components with lower ratings may also be used in some cases, providing the ratings are not exceeded.

available size of gang. There is also a variable trimmer across each section of the gang. These, together with the slugs in each of the coils, provide for correct alignment and band coverage. Output from the oscillator is taken from the emitter via a 1pF capacitor to provide injection into the gate of the FET mixer.

The components used in the converter are normally stocked items and no trouble should be experienced in obtaining a complete kit. The types of capacitors required are shown in the parts list.

For the mixer transistor, there are at least four different type numbers which we know to be suitable. These are 2N5485, FE5485, MPF106 and BFW11, all having substantially the same characteristics. The oscillator transistor is a bipolar and such types as BF115, TT1002, SE1002, or similar should be satisfactory in this position.

The prototype printed circuit board was made by RCS Radio Pty Ltd, but there are quite a few manufacturers of printed circuit boards and suitable boards may be also available from other makers. As mentioned in previous articles on converters, we have attempted to make this a multi-purpose board and during assembly, you will notice that there are many unused holes. To avoid any possible errors due to the extra holes, I suggest that extra care be taken during assembly.

The output transformer is an RCS type 253 broadcast aerial coil connected in reverse. Possibly other brands could be used, provided they can be made to fit the space on the printed board.

The dial assembly calls for special comment, particularly as the "Jabel" dial used on the prototype is no longer available in this form, having since been modified. The actual mounting centres have been retained but the height has been increased by about 12mm. This means that the front panel has to be increased in height. This has been taken care of in the dimensions given in the parts list, and the metalwork drawing has also been altered to suit.

A good place to start construction is to wind the aerial and oscillator coils. The aerial coil consists of a primary and a secondary, with the secondary wound first. The start of the winding is anchored by soldering it to the lug of the former, according to the drawing. The finish of the winding may be temporarily held in place with a small piece of adhesive tape. Leave this end free while the primary of two turns is wound over the bottom end of the secondary. The start is anchored by soldering it to the appropriate former lug and the finish may also be held in place by drawing it tightly and soldering it to its lug. The finish of the secondary is now soldered to its lug.

The oscillator coil is treated in much the same way, except that it only has one winding. Keep it in mind that the frequency stability of the oscillator largely depends on this coil. It should therefore be wound firmly and finished in a workmanlike manner. The start and finish must be soldered to the lugs as shown in the drawing, so that the connections suit the pattern on the printed circuit board. To ensure that the windings of both coils stay firmly intact, they should now be given a coat of cellulose lacquer or other suitable material.

Before the 2-gang variable capacitor

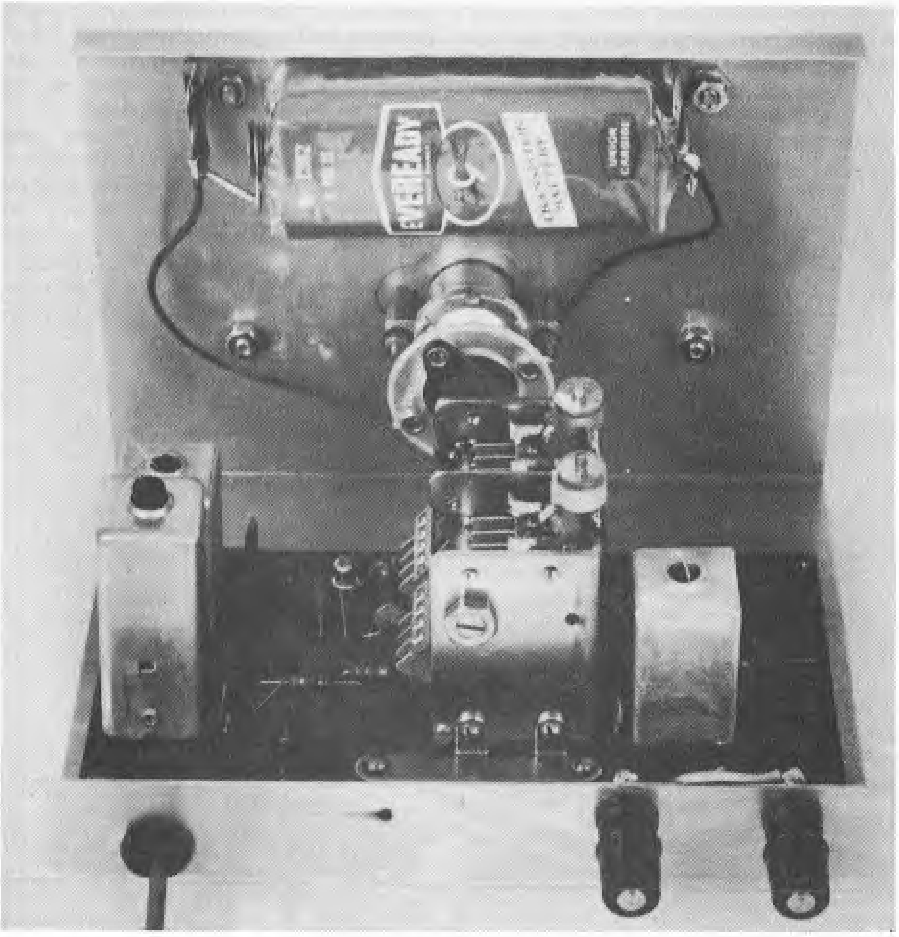
can be fitted to the board, leads must be soldered to the two bottom lugs of the fixed plates. About 50 mm of 20 gauge tinned copper wire should be used, with a loop wound firmly around each lug before soldering. This will prevent the soldered joint from coming adrift when the other end of the lead is soldered to the board. A trimmer must also be soldered to each section of the gang and as may be seen from the picture, we used the newer solid dielectric type. If you have the old "beehive" trimmers, then use them by all means.

Care should be taken when soldering the gang trimmers in place. Make sure that good soldered joints are made, without damaging the trimmers by burning or overheating.

Possibly the most interesting part of the construction is assembly of the printed board. Although this is a straightforward job, it is advisable to approach it in a systematic manner. A good place to start is with the resistors, followed by capacitors and other small items, including the transistors. Do not forget the link, which may be a piece of tinned copper wire or even a scrap of pigtail from a resistor. Note that the 10pF coupling capacitor across the output transformer, the 1pF injection capacitor, the .01uF bypass capacitor across the 4.7k resistor and the zener diode are all mounted underneath the board.

In some earlier converters we used an aerial coil made by RCS Radio as the output coil. These coils were originally designed for use in valve receivers and they are no longer made. The aerial coils made for use with transistor receivers are quite satisfactory, but some of the coil connections are different. This problem may be solved in one of two ways. You may open up the coil if you feel competent to do so, and change some of the terminations to fit in with the existing board. The alternative is to make a cross connection to the appropriate point on the copper.

I chose to change the terminations, and this is how it is done. Leave the connections to "G" and "P" unchanged. (These markings are moulded into the base adjacent to the pins, except the tap.) Lift the lead to "F" and leave it free for the time being. Lift the lead to "B" and immediately resolder it to "F". The floating lead is now soldered to the tap pin.



This rear view shows the main disposition of components, including the flexible dial drive coupling. The oscillator coil is at left, nearest the front panel.

As the board was made to accommodate Neosid coil formers, and we are using a coil made by RCS Radio in this instance, some care is needed in fitting this transformer. The following procedure is suggested.

Cut off the fifth or tap pin close to the moulding, or bend it over so that there is no chance of it becoming short circuited when fitted. Now bend each of the remaining four pins over so that they lie over the corners of the can. Then the pins are bent in dog-leg fashion such that they will enter the four holes in the printed board. The can mounting lugs must also be bent inwards and in a similar manner so that they will pass through the respective holes in the board. This done, the can may be mounted—but care must be taken to ensure that it is orientated correctly, according to the code on the circuit and that moulded adjacent to the pins.

If you decide not to change the coil terminations, I suggest that you go about it this way. Do not cut off the tap pin but bend it over as previously suggested. Solder a short length of insulated hookup wire to the bent tap pin, making sure that no short circuit will be created later on. Mount the coil as described previously, but run the hookup wire through the centre slug adjusting hole in the board. Solder pins "G", "F" and "P" but do not solder "B" to the copper pads. Instead, run the lead of hookup wire to the pad adjacent to "B".

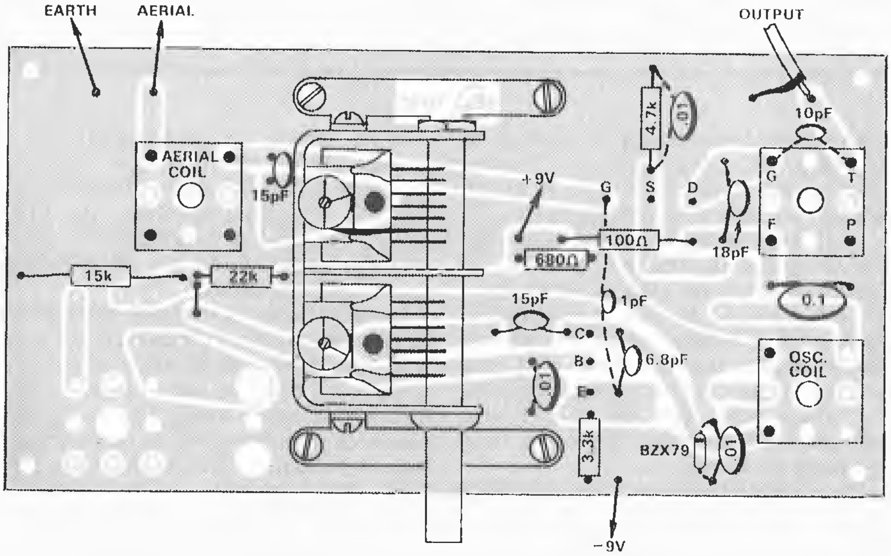
Fit the aerial and oscillator coils into their cans and bend the lugs over so that when the screws are used for mounting, they will contact the side of each hole. This is to ensure that the can is connected to the earthed copper. Each coil is fixed to the board with two 6BA screws. If 6BA screws are not readily available, the alternative is to re-tap the holes to ⅛in Whitworth.

The 2-gang capacitor is fixed to the board with four screws. An option is to add two extra PCB mounting spacers under the board, to two of the screws, one nearest the front panel and adjacent to the oscillator circuitry, with the other diagonally opposite. The other four spacers are fitted at each corner of the board.

This completes the assembly of the board, except for some leads which must be provided to go to external points. Leads of sufficient length are soldered to the earth point near the earth terminal on the back skirt of the chassis, the aerial point of the coil to the aerial terminal, the +9V point to the switch and a lead from the copper earth for the negative terminal of the battery. The coax cable is connected with the inner conductor to the output point and the braid is soldered to the earth copper nearby.

The two terminals, rubber grommet,

27MHz converter



The component layout shows the PC board as viewed from the component side. Pay particular attention when inserting polarity conscious components.

switch, dial assembly and battery may now be fixed to the chassis-panel. As we mentioned earlier, the dial we used is no longer made but if you have one, then it may be used, as the mounting holes remain the same. Alternatively, the new dial may be used as suggested, or you may make your own arrangements as you see fit, possibly by still making use of the dual ratio dial drive by Jackson Bros. This drive is available as a separate item from Messrs Watkin Wynne, 32 Falcon Street, Crows Nest, NSW 2065.

The complete dial assembly is supplied with a scale, having in addition to a 0-100 logging scale, four blank ranges, which may be calibrated according to actual needs. However, calibration of this may present problems to those readers who do not have any instruments for calibrating. To help with this problem, we are printing a full size scale so that you may cut it out and use it directly, or you may take the information and mark it on the scale provided on the dial assembly.

When mounting the dial assembly, we suggest that you make provision for the battery by adding a large 3-tag strip under each of the two top screws. The battery may then be strung across these strips as may be seen in the picture.

At this stage, a careful check should be made to ensure that no errors have been made on the board assembly and elsewhere. Satisfied that all is well, the board may now be screwed to the chassis, not forgetting the flexible coupling between the gang and the dial drive. A short spindle is required between the drive and the coupling and this may be obtained from an offcut of a potentiometer spindle.

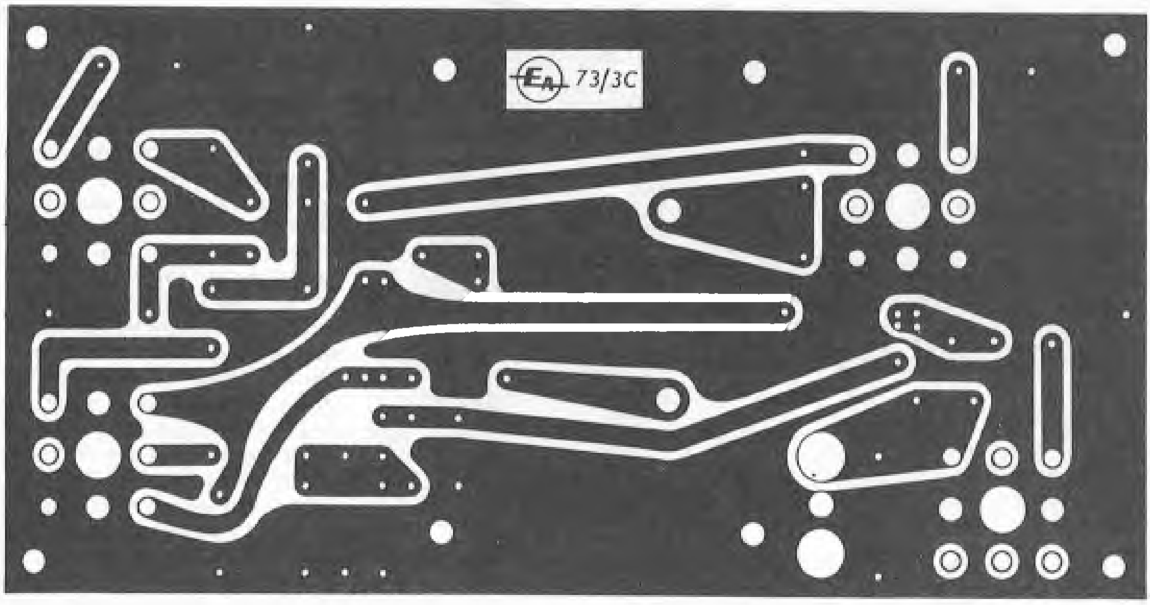
All interconnecting leads are now terminated to the respective points. The negative battery connection may be tied to the earthed lug on the appropriate tag strip, whereas an insulated lug will be used for the positive connection at the other end. If you use heavy gauge tinned copper wire for these connections, it should be sufficient to hold the battery in place. However, if you wish, an extra bracket may be fitted according to your own ideas.

Having completed the mechanical work, the converter is ready to be put into operation. Quite a number of items must be considered here. We will assume that you have a suitable broadcast receiver into which to feed the converter. We will also assume that you have an aerial which is efficient at 27MHz. Hopefully, you will also have access to a signal generator or modulated oscillator which you may use to align and adjust the calibrations against the dial scale. If not, then you will have to use whatever information you can relating to the frequency of received signals and try to adjust the dial calibrations accordingly.

If you have an ordinary broadcast receiver with aerial and earth terminals and without a ferrite rod aerial, then you may feed the output coax cable directly into the aerial and earth terminals. On the other hand, if you have a small transistor personal portable receiver, or a larger receiver with a ferrite rod aerial fitted, then you may use this instead. However, some preparation is necessary before you can use this type of receiver.

The simplest way is to get a few yards of insulated hookup wire. After determining which way the ferrite rod aerial runs inside the receiver, wind from six to ten turns of hookup wire around the receiver so that the ferrite rod is parallel with the axis of your winding. The winding may just be bunch wound and the

Below is an actual size reproduction of the PCB pattern.



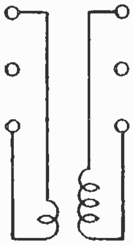
two insulated ends twisted together to hold the winding in place. Now bare the two ends and solder them to the two connections of the coax cable from the converter.

The above method is quite a rough looking job but works very well. However, if you wish, then it is up to you to devise a more neat way of winding and arranging the turns around the receiver. On the other hand, if you wish you may be able to open up the set and if space permits, wind six turns or so directly around the ferrite rod, again using insulated hookup wire and terminating it to the cable from the converter.

Switch on the receiver and tune right down to the high frequency end of the dial, so that you have just tuned past station 3NE, or 1600kHz. This will ensure a clear spot as your first intermediate frequency. The receiver should be left tuned to this position. Switch on the converter and with the volume control on the receiver set to a suitable level, adjust the slug in the converter output coil for maximum noise or hiss. You may find that the slug will protrude somewhat above the top of the can. If this is excessive, then the 18pF capacitor should be reduced to 15pF.

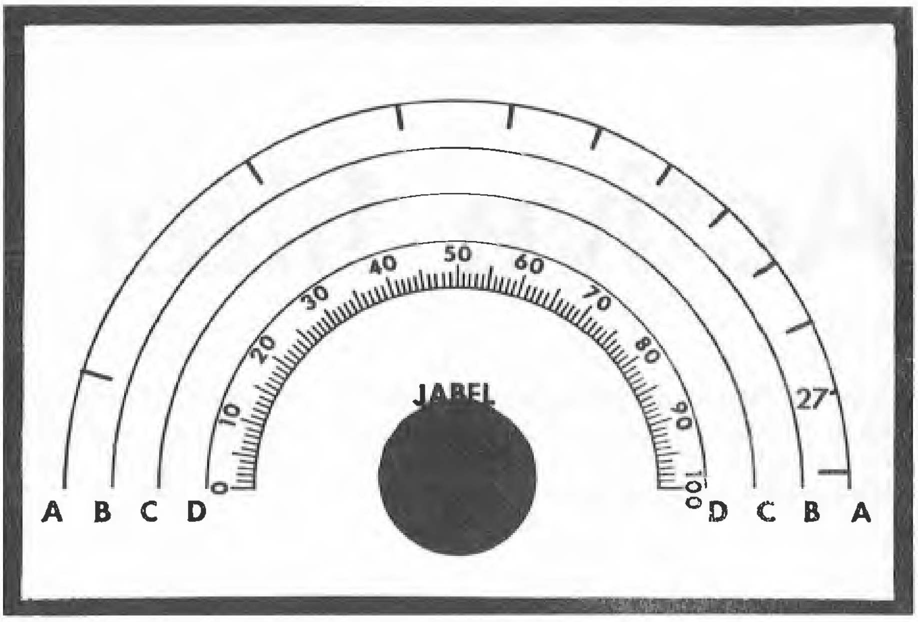
As an alternative to setting the receiver tuning just outside the broadcast band, you may wish to choose a lower frequency. However, this has problems of broadcast stations breaking through, particularly at night. To reduce this possibility, you may be able to rotate the receiver to null out the interfering station, or perhaps even stand the receiver on end to reduce pickup of the ferrite rod.

Coil Winding Details



COIL CONNECTIONS VIEWED FROM ABOVE

COIL DETAILS
Aerial coil: Tuned winding, 15 turns 30B&S enamel wire on Neosid 7.6mm former. Coupling winding, 2 turns 30B&S enamel wire wound over earthy end of tuned winding. Use grade 900 slug and mount in can.
Oscillator coil: One winding, 15 turns 30B&S enamel wire. Other details as above.



This full size reproduction of the dial scale may be either copied or used direct. The blank ranges may be calibrated according to requirements.

Assuming that you have a calibrated signal generator available, set it to 27MHz and feed it into the aerial of the converter. Set the converter dial pointer to 27MHz. Adjust the slug in the oscillator coil until the generator signal is heard. Also adjust the slug in the aerial coil for maximum response. Keep the signal generator level such that only sufficient signal is fed in to make effective adjustments to the slugs and trimmers.

Now set the signal generator to 27.9MHz and set the converter dial pointer to 27.9MHz, which is the last point towards the other end of the dial. Adjust the oscillator trimmer until the signal is heard and then adjust the aerial coil trimmer for maximum response. As always, when aligning a superhet receiving system, this process must be repeated several times until the calibrations are set at the correct points near each end of the dial respectively.

Each time the oscillator coil slug or trimmer is adjusted, the slug or trimmer on the aerial coil should also be adjusted.

If you are unable to obtain the use of a signal generator for calibration and alignment, then it will be a matter of making use of whatever facilities may be available. If you do not have any means of generating a signal yourself, then a friend may be able to help. It should not be very difficult to identify a signal of known frequency around 27MHz and so calibrate that end, but it may be more difficult to get a calibration for the other end.

Although about as simple as it could be, this little converter can give a very good account of itself given a broadcast receiver of reasonable sensitivity and a good aerial system. I have tried the prototype, using an aerial for amateur bands from 3.5MHz to 28MHz and feeding it into a portable transistor receiver with a ferrite rod and I was more than surprised at the performance. At nights and at weekends, many signals may be tuned in with good reception.

If you would rather feed the converter into a short wave receiver which will tune around 3.5MHz but does not tune right up to 27MHz, then this may be done by substituting for the RCS aerial coil with one of your own winding. Use a Neosid former 7.6mm diameter and 60mm long, with two grade 900 slugs and a can. Wind a primary with 120 turns of 28B&S enamel wire and terminate to suit the tuned winding on the board. The output or secondary winding consists of 12 turns of the same wire wound over the earthy end of the primary. It is terminated to suit the output on the board. The tuned winding is shunted with an 82pF NPO ceramic or a polystyrene type.

Having done this, it will be necessary to set it to frequency by whatever means you have available and align and calibrate the rest of the unit. There is one point however. It is not likely that the calibrated dial scale which we used on the prototype will be accurate for this application. No doubt readers wishing to do this will have facilities to do their own calibrating.

BASIC ELECTRONICS

Basic Electronics, now in its fifth edition, is almost certainly the most widely used manual on electronic fundamentals in Australia. Begins with the electron, introduces and explains components and circuit concepts, and progresses through radio, audio techniques, servicing, test instruments etc.

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Electronics Australia
Box 163, Beaconsfield, NSW 2014.

Versatile PCB can be used for active crossovers

Active filter unit

If you are interested in active crossovers and related subjects, this article should interest you. In it, the author describes the design and construction of a third-order Butterworth filter based on commonly available op amps.

by DAVID EDWARDS

The most common method of amplifying the output of a preamplifier into the large signal required to drive a loudspeaker is to use a single power amplifier having a flat frequency response over the audio spectrum. Such amplifiers have evolved to the state of being almost perfect, adding very little distortion to the signal being amplified.

Very few satisfactory designs have been developed, however, for single speaker drive units which will cover the complete audio spectrum. This has meant that several drivers, each handling a portion of the audio spectrum, are required to construct a wide range loudspeaker system.

An immediate corollary of this is that the audio spectrum must be divided into suitable portions, so that each driver receives only signals within its range. Signals outside the required range must usually be attenuated, in order to avoid nonlinearities due to mechanical resonances and cone breakup.

The conventional way of doing this is to use passive crossover networks, which take the amplifier output and split it up (frequency wise) in the desired manner. In order to achieve the required cutoff rates, and to ensure that losses are kept to a minimum, large non-polarised capacitors and low resistance inductors are required.

Unfortunately, such components are expensive, and to design and construct suitable crossovers requires a good deal of experience.

An alternative procedure is to divide the spectrum before the main power amplifier, and then to use separate power amplifiers for each driver. Since the splitting is being performed at low signal levels, active filter networks, requiring only cheap (relative) components can be used.

There is a tradeoff, of course, in that more power amplifiers are required, although this may be partially offset by the saving in crossover components. However audible advantages can accrue from the use of separate amplifiers.

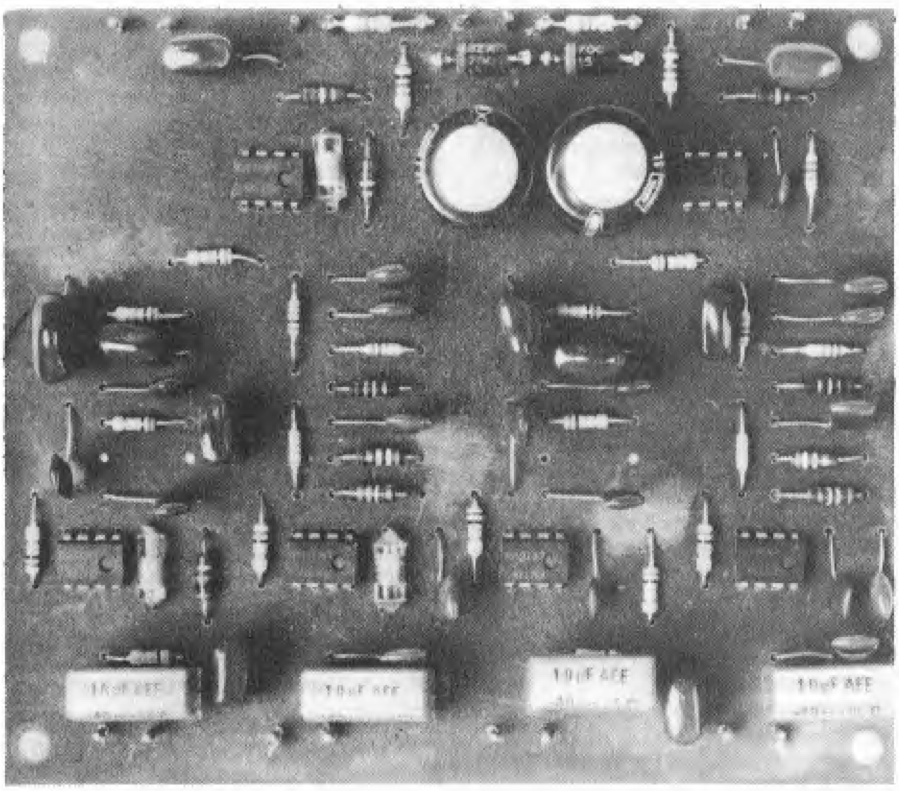
The main advantage is that intermodulation distortion in the amplifiers is reduced, because each amplifier is only called upon to amplify a portion of the audio spectrum.

The individual drive units may also have improved responses, because they are driven directly from amplifier outputs, and hence from low source impedances. Conventional crossover networks tend to degrade the damping factor, especially with regard to bass drivers and in the vicinity of the crossover frequencies.

The designer's task is considerably eased also, as it is much easier to alter and experiment with the parameters of an active filter than it is with those of passive filters. In addition, the parameters of active filters can be more easily controlled, and sharper cutoffs can usually be provided, as well as compensation for driver units with different sensitivities.

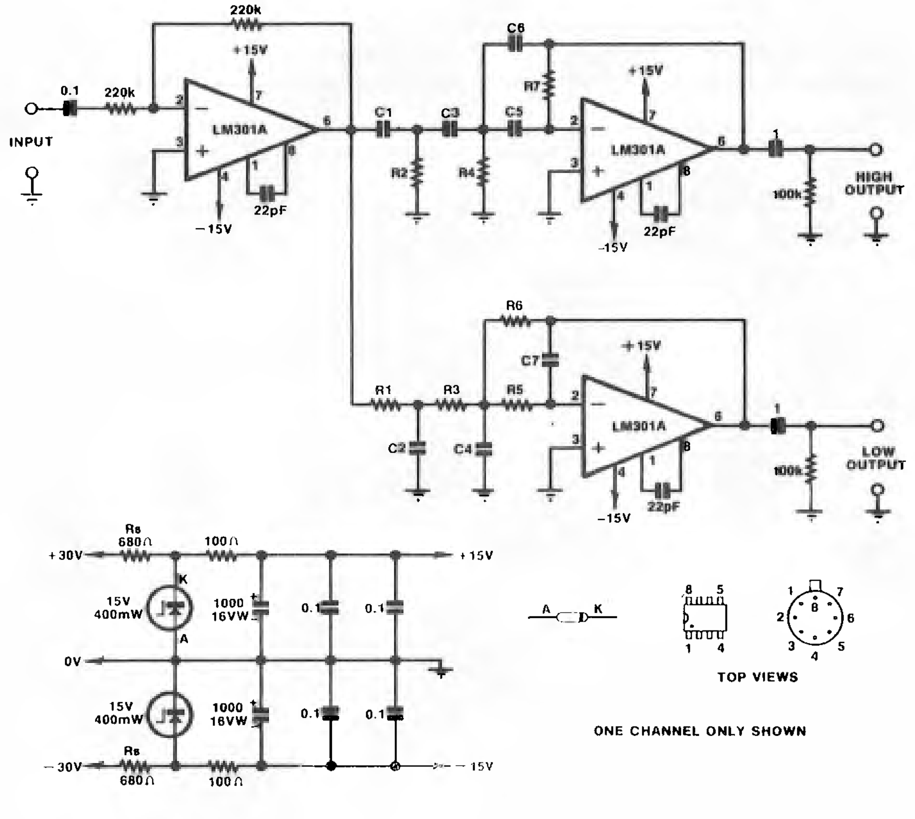
The impetus for the design presented in this article came from the author's desire to improve his own stereo system. The idea was to provide a seperate bass enclosure from that housing the mid-range and treble units.

After much thought and discussion, it was decided to cross over to the bass



In this view of the completed board, the power supply components are at the top, while the filter circuits are at the bottom.

driver at 300Hz, using an active crossover. The idea of combining the two bass signals from a stereo amplifier to form a mono signal, and then using a single amplifier, was abandoned because it seemed easier to build a 25W stereo amplifier (the Twin Twenty Five) than one 50W amplifier.



3RD ORDER BUTTERWORTH ACTIVE FILTER 1/FI-

This circuit diagram shows only the power supply components and the components required to implement two of the four filters required for a stereo unit.

The next design consideration was the type of active filter to be used. Ideally, a constant voltage design, in which the vector sum of the outputs is equal to the inputs is the best choice, with a second requirement being that the design should be constant power (i.e., no peaks or dips in the overall passband).

A first-order Butterworth filter satisfies both these requirements, but has cutoff slopes of only 6dB per octave. Higher-order Butterworth filters satisfy the latter requirement, but are not constant voltage designs, although they have quite sharp rolloffs.

Constant voltage designs can be realised using the subtractive method, in which say a high pass function is achieved by subtracting the output of a low pass filter from its own input. But these designs are not of constant power, and tend to have unequal rolloff rates.

Having just deduced that no filter shape or generation method is completely satisfactory, it was necessary to find the least of the various "evils". In order to prevent directionality information from being produced by the bass driver, we required a sharp cutoff filter. Second-order Butterworth designs were rejected on the grounds that they produce severe phase shifting at frequencies near the crossover.

Third-order Butterworth designs, however, are much more acceptable. While there are phase shifts at the crossover frequency, the rate of phase change of the resultant signal is gradual, and this reduces the audibility of the change. In addition, since it was intended to have the bass units physically separate from the midrange and treble units, this phase change would not be as noticeable, due to the effects of room reverberation.

While the basic design of the crossover described is intended for the purpose outlined above, I believe it will be suitable for use at higher frequencies, with driver units in close proximity, where rapid attenuation in the stop band is required. Such cases arise for example, where a tweeter resonance has to be suppressed, while still maintaining operation close to the resonance.

So the information contained in this article will enable you to design and build third-order high and low pass Butterworth filters with crossovers at any desired frequency in the audio range.

Turning now to the circuit diagram, we can discuss the way in which the design has been implemented. LM301A type IC operational amplifiers have been used as the basic circuit gain element. 22pF compensation capacitors have been specified, to give a compromise between slew rate (which determines high level high frequency response) and stability.

Plus and minus 15V supply rails are provided to ensure adequate overload margin, compared to the nominal signal level of 1V RMS. The noise performance of the op amps is such that a signal to noise ratio in excess of 65dB with respect to 1V RMS can be obtained, and a total dynamic range of about 85dB.

A unity gain inverting buffer is provided at the input, to ensure an adequate low impedance drive to the following filter circuits, and to provide overall non-inverting response (the filter circuits alone have inverting characteristics).

An input capacitor is provided, and the input impedance is 220k, as set by the input resistor. Two filters are driven from each buffer, one connected as a high pass and one as a low pass. Each filter utilises a single op amp.

A 1uF output coupling capacitor is provided for each filter. With the recommended 10k (minimum) load, this gives a -3dB point of 20Hz and minimises the effects of low frequency noise produced in the input circuits of the op amps. If higher load impedances are provided, these capacitors should be reduced in value, giving the same 20Hz rolloff point.

Zener diodes are provided to regulate the supply rails, with 100 ohm/1000uF combinations used to reduce ripple even further. Total current drain is approximately 20 mA per side. By varying the input dropping resistors, it is possible to operate the unit over a wide range of input supply voltages.

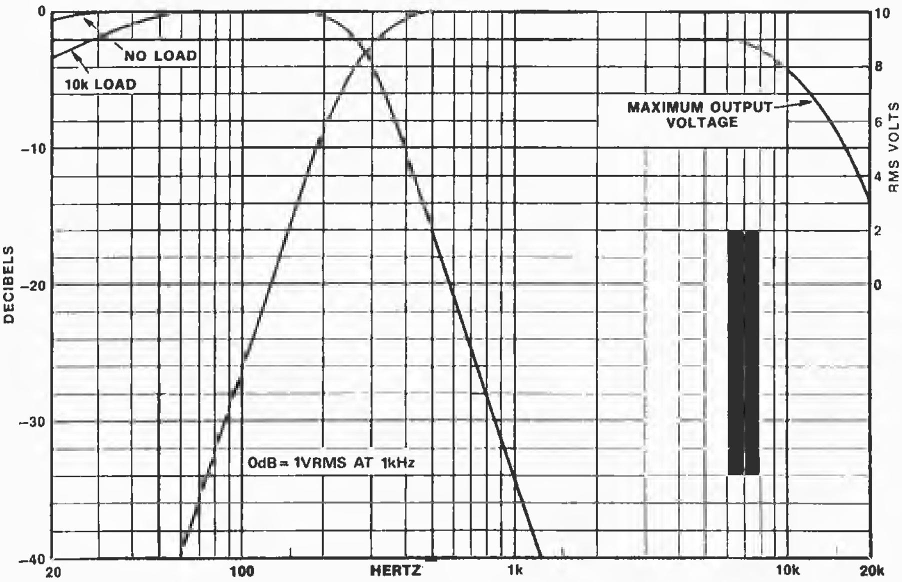
In order to aid in calculating the required values for different filters, we have provided a table of most likely required values, as well as details of the actual calculations. If you wish to use one of the crossover frequencies listed in the table, simply use the values tabulated with the desired frequency.

The columns labelled "pref" show the preferred value components required to be connected in parallel to obtain close approximations to the calculated values.

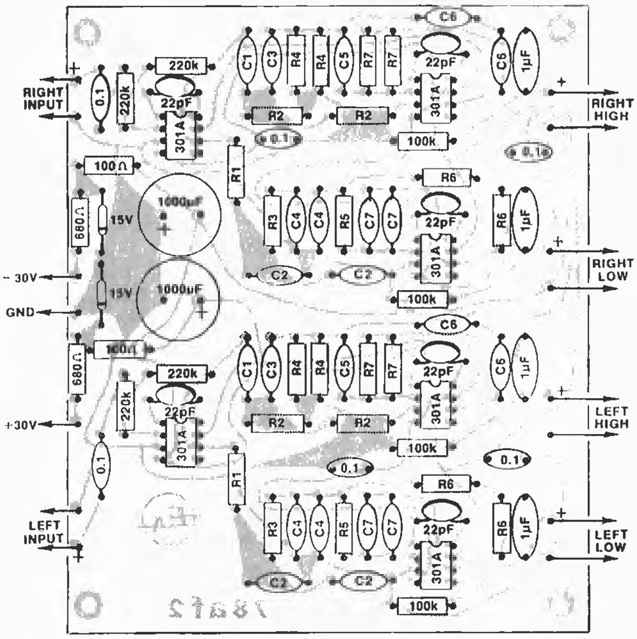
To see how the table was derived, we suggest you work through an example, using the method given below. This method will also be applicable to those who require crossovers at non-tabulated frequencies.

The first step is to choose the appropriate crossover frequency, fo. Then select R1 =10k, to set the input impedance of the filter at 20k. Next, calculateC1 = 1/(2.pi.fo.20000). Round the result of this calculation off to the

Active filter unit



FREQUENCY RESPONSE OF 300Hz (NOMINAL) 3RD ORDER BUTTERWORTH FILTER



ABOVE LEFT: The response of the prototype is shown in this graph, as well as the maximum output voltage.

LEFT: Use this overlay diagram as a guide when mounting the components on the printed circuit board.

RIGHT: This table gives preferred values of components required to construct filters with a variety of crossover frequencies.

nearest preferred value.

R3, R5 and R6/2 are all made equal to R1, while C3, C5 and C6/2 are all made equal to C1. The passband gains are determined by R6, R1 and R3, and by C6, C1 and C3, so in order to set the gain at unity, R6 and C6 are formed by series-connected units.

The next stage in the procedure is to calculate Req = 1/(2.pi.fo.C1), and Ceq = 1/(2.pi.fo.R1). These values are then used to determine the remaining unknown values, using the formulae listed below:

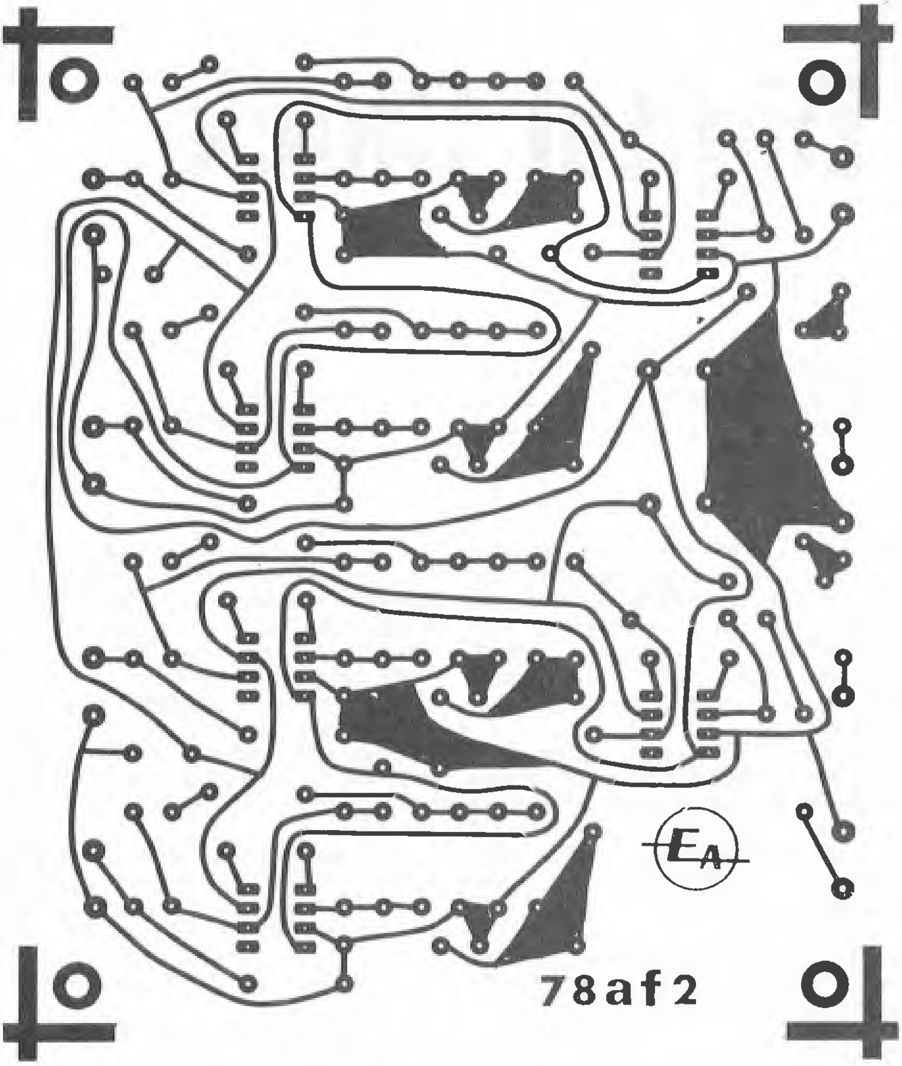
R2 = 0.407Req; R4 = 0.474Req;
R7 = 5.177Req
C2 = 2.455Ceq; C4 = 2.109Ceq;
C7 = 0.193Ceq

These last six values will have non-standard values, so in order to achieve optimium cutoff slopes and matching of the crossover frequencies, it will be necessary to use two standard value components to approximate to the calculated value. The combination charts represented in the June 1975 issue, and again in the 1976/1977 Yearbook will be found to be invaluable in this respect.

In order to simplify the design of the printed circuit board, we only provided for parallel components, so this must

fo(Hz)	C1 (uf)		Req (ohms)	Ceq (uf)	R2 (k)		R4 (k)		R7 (k)		C2 (uf)		C4 (uf)		C7 (uf)	
	calc	pref			calc	pref	calc	pref	calc	pref	calc	pref	calc	pref	calc	pref
100	.0796	.082	19409	.159	7.89	8.2//220	9.20	10//120	101.5	100	.390	.39	.335	.33	.0307	.027//.0039
300	.0267	.027	19649	.0531	8.00	10//39	9.31	10//150	100.7	100	.130	.12//.01	.112	.1//.012	.0102	.01
500	.0159	.015	21221	.0318	8.64	10//68	10.06	10	109.9	220//220	.0781	.039//.039	.067	.068	.00614	.0056//.00056
700	.0114	.010	22736	.0227	9.25	10//120	10.78	18//27	117.7	120	.0557	.056	.0479	.015//.033	.00438	.0039//.00047
1000	.00796	.0082	19409	.0159	7.89	8.2//220	9.20	10//120	100.5	100	.0390	.039	.0335	.033	.00307	.0027//.00039
2000	.00398	.0039	20404	.00796	8.30	12//27	9.67	18//270	105.6	120//820	.0195	.018//.0015	.0168	.015//.0018	.00154	.0015//.000039
4000	.00199	.0022	18086	.00398	7.36	10//27	8.57	10//68	93.6	100//1500	.00977	.01	.00839	.0082//.00018	.000768	.00068//.000082

Active filter unit



This full sized reproduction of the PCB pattern can be used to make your own circuit boards. It can be used direct or traced.

be born in mind when selecting values. We found that 5% or 10% components were satisfactory in practical use, although theoretically 1% components should be used for optimum results.

We have designed a small printed circuit board, coded 7af2, and measuring 110 x130mm. This has provision for two channels of the circuit shown in the diagram, and utilises six op-amps in all. Assembly of the components onto the board should be straightforward, using the component overlay diagram as a guide.

PCB pins are recommended for all external connections to the board; 15 will be required. Care is required when completing the external wiring to avoid earth loops, as these will almost certainly increase the hum level.

The performance of the prototype is shown in the accompanying specification table and frequency response graph. The high frequency rolloff in the maximum output voltage curve is due to slew rate limiting. In practice, of course, high frequency high level signals are fairly rare, and this does not cause, any audible deterioration in typical signals.

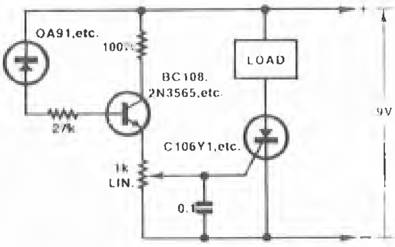
In conclusion, we would like to point out that the unit can be used as a signal processing unit, as well as an active crossover network. If all filters were made high pass, with rolloffs at say 7kHz and 15kHz, the board could be used as a switched scratch and hiss filter. Note, however, that it cannot be used as a rumble filter, because such a filter should be at the input of a system and the inherent noise of this present design is too high to allow it to be inserted in the signal chain before the preamplifier.

PARTS LIST

6 LM301A 8-pin DIL or metal can operational amplifiers
2 15V 400mW zener diodes
1 printed circuit board, coded 77af2, 110 x 130mm
15 PCB pins
2 1000uF 16VW pigtail PCB mounting electrolytic capacitors
4 1uF polyester capacitors
6 0.1uF polyester capacitors
6 22uF ceramic or polystyrene capacitors
C1, C2, C3, C4, C5, C6 & C7 (see text)
4 220k ½W resistors
4 100k ½W resistors
2 680 ohm ½W resistors
2 100 ohm ½W resistors
R1, R2, R3, R4, R5, R6 & R7 (see text)

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with higher ratings may generally be used provided they are physically compatible.

Temperature actuated switch



This simple circuit for a temperature switch may be used in many applications. The temperature sensing device is a germanium diode operating under reverse bias conditions.

When the voltage on the gate electrode of the SCR becomes great enough, the SCR is triggered into conduction, and continues to conduct until the unit is turned off. The temperature at which triggering occurs is determined by the setting on the 1k pot.

A slight modification can be made to alter the mode of operation: apply 9V DC to the diode and transistor and 6.3V AC to the SCR/load combination; delete the 0.1uF capacitor across the SCR gate; and add a 1000uF electrolytic across the load.

The SCR will now conduct when the temperature rises above the set value, and turn off automatically when the temperature falls below this value. (D. M. Green.)

Versatile new design offers several options:

Modular Digital Clock

Here is our simplest-ever digital clock project. In its basic form, all that is required is a clock module, a transformer, two switches and a case. But if desired it can be expanded to include alarm, snooze, sleep and radio switching functions.

by DAVID EDWARDS

At the heart of this new digital clock is a new clock module recently released by National Semiconductor. Designated the MA1002 LED display electronic clock module, it is available in eight different versions. Current retail price of individual modules is currently around the $14.00 mark.

Each module consists of a monolithic MOS-LSI integrated clock circuit, four digit 13mm LED display, power supply and other discrete components, all mounted on a single printed circuit board. Perhaps the most unusual feature of the assembly is that both the clock chip and the display LEDs are mounted directly onto the circuit board, without the use of conventional IC packages.

As you can see in the accompanying photographs, the clock chip is centrally mounted under a blob of epoxy. The LEDs are mounted on the other side of the board, and protected by a red plastic lens, which also serves to provide optical magnification for them.

There are only fifteen other discrete components on the board, and these are dominated by a power transistor and its associated heat sink. The overall size of the complete module is a tiny 77 x 35 x 17mm.

All that is required to turn the module into a functioning clock is a mains transformer and switches, as well as the usual mains lead and mounting hardware. Eight different modules are available, and these are distinguished by suffixes A to H. Modules A, C, E, and G, are all intended to operate from 60Hz mains supplies, and are not of much interest to us at this stage.

Modules B, D, F and H are the 50Hz versions. Types B and F have a 12 hour display (with PM indication) while types D and H have 24 hour displays. Types B and F are intended as clock radios, while types D and H are intended as alarm clocks.

All modules have alarm facilities, incorporating a nine minute "snooze" delay. This turns off the alarm for nine minutes, and then sounds it once more. This process can be repeated for an hour (by which time you will be very late for work!).

Provision is made for varying the display intensity, either manually or automatically (using an LDR or similar device). There is also a sleep output which allows a radio or similar device to be turned off after a programmable delay of up to 59 minutes.

Let us consider first the alarm clock versions (F and H). These versions incorporate an additional small signal transistor, connected as an oscillator controlled by the alarm output of the clock chip. This oscillator is intended for use with a low cost earphone audio transducer, which must have a resistance of 500 ohms and an inductance of 100mH.

All that is required to build an alarm clock with snooze facilities is this earpiece, along with the clock module, transformer, case and switches. Construction is reduced to mounting the various parts in the case, and wiring them together.

Note that the sleep facility is included with the alarm clock versions, so that if desired, a radio or similar appliance can be controlled by the clock as well. This is done in the same way as for the clock radio versions, which will be described next.

The clock radio versions (types B and F), differ from the alarm clock versions only in that the alarm oscillator is not included. However, the alarm output is still available, so that this can be used to control a separate alarm unit.

The most commonly available module will be the B type (12 hour 50Hz clock radio), so our discussions from now on will centre on this type. The other types of module are essentially similar, so that the circuits to be presented can be used with them.

Fig. 1 shows the basic clock circuit. A transformer is required with two secondary windings, connected as shown. The 16V winding should have a current rating of at least 25mA, while the centre-tapped 10V winding should be able to supply up to 250mA. One end of the 16V winding is connected to the centre tap of the 10V winding.

The 16V winding is used to power the clock chip itself, while the other winding supplies the display LEDs. This reduces the dissipation in the display drivers. The display is driven directly (i.e. it is not multiplexed), so that radio interference is reduced.

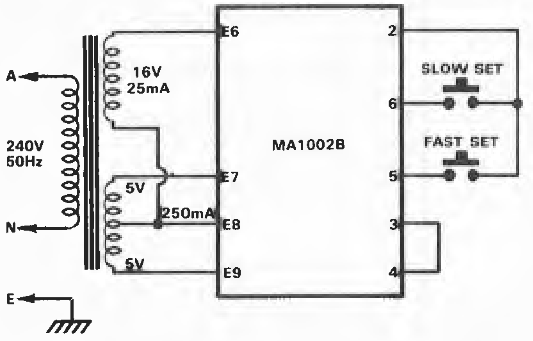
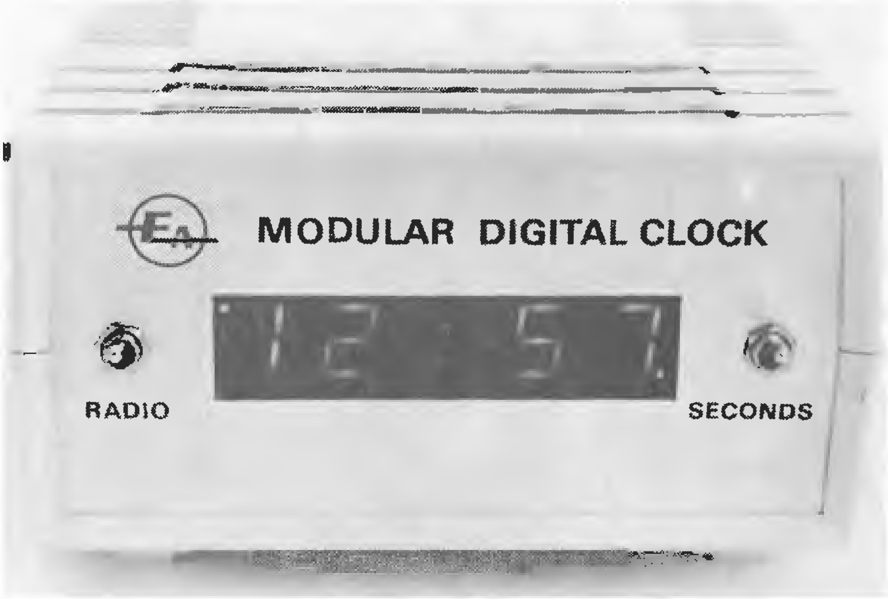


FIG. 1 BASIC CLOCK

The circuitry shown at left is all that is required to make up the clock in its most basic form. The basic clock module can be purchased with either a 12 or a 24 hour display.



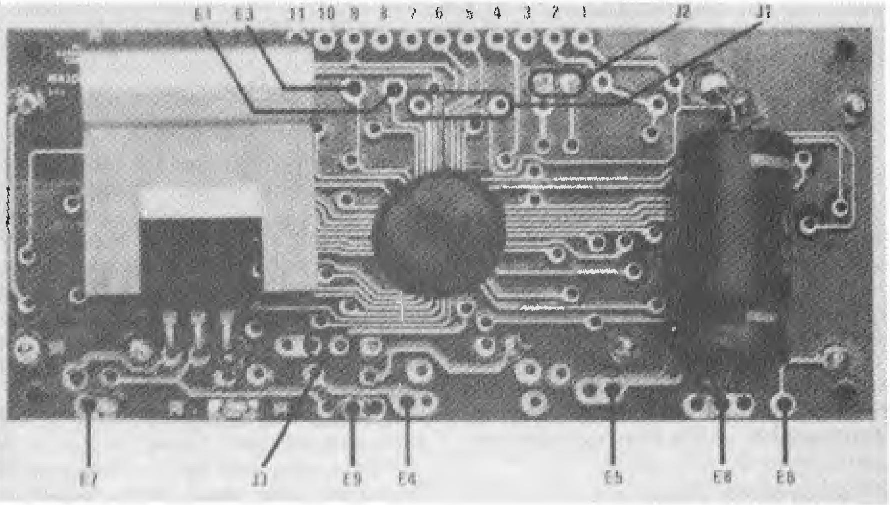


Fig. 2 (above) shows the location of the various connection points on the clock module. Exercise due care when soldering to the board, as discussed in the text.

PARTS LIST

BASIC CLOCK
1 National Semiconductor MA1002B clock module (see text)
1 transformer, 240V to 16V and 10VCT (A & B 9827, J.T. 197 or similar)
2 momentary contact switches
1 case, see text
2 aluminium clamps, see text
Solder, hookup wire, machine screws, mains cord, cord clamp, grommet terminal block

EXTRA PARTS FOR FULL FEATURE CLOCK
1 printed circuit board, coded 76cl12, measuring 76 x 50mm
2 BC548 NPN transistors
1 BC558 PNP transistor
1 C106Y1 SCR, or BRY39 SCS, or similar
2 EM401 silicon diodes
1 1N914 silicon diode
1 3.6V 400mW zener diode
1 ORP12 light dependent resistor
1 22k trimpot
1 10M, 1 100k, 3 10k, 1 6.8k, 1 1k ¼W resistors
1 470uF 25VW PCB mounting electrolytic capacitor
1 100uF 10VW PCB electrolytic capacitor
3 SPST miniature toggle switches
1 SPDT centre-off miniature toggle switch
1 alarm unit, see text
1 radio unit, see text
Tinned copper wire, rainbow cable, machine screws
NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with high ratings may generally be used provided they are physically compatible.

To implement the basic clock, only two switches are required. These should be momentary contact types, and are used to set the time. They are connected as shown between pads 2, 5 and 6 of the module, with a link connected also between pads 3 and 4.

When power is first applied, the display will show some random time, and it will be flashing at a 1Hz rate. This is the power failure indicator. When either of the time setting switches is operated, the display will remain steady, with the colon flashing at one second intervals. This shows that the clock is counting, and also gives some indication of the passage of seconds.

PM indication is by means of a small dot in the upper left hand corner of the display. When this is illuminated, the clock is in the PM phase.

Fig. 2 shows the location of the various connection points on the clock module. If desired, this simple clock can be assembled, either for use as it stands or preparatory to adding the more exotic functions, such as the alarm and radio features.

Turning now to Fig. 3, we can discuss the full feature clock. Switches S1, S2, S3 and S4 are all momentary contact types, and control respectively setting of the time, setting of the snooze, and seconds display facilities. When this latter switch is operated, the display shows minutes, tens of seconds, and seconds.

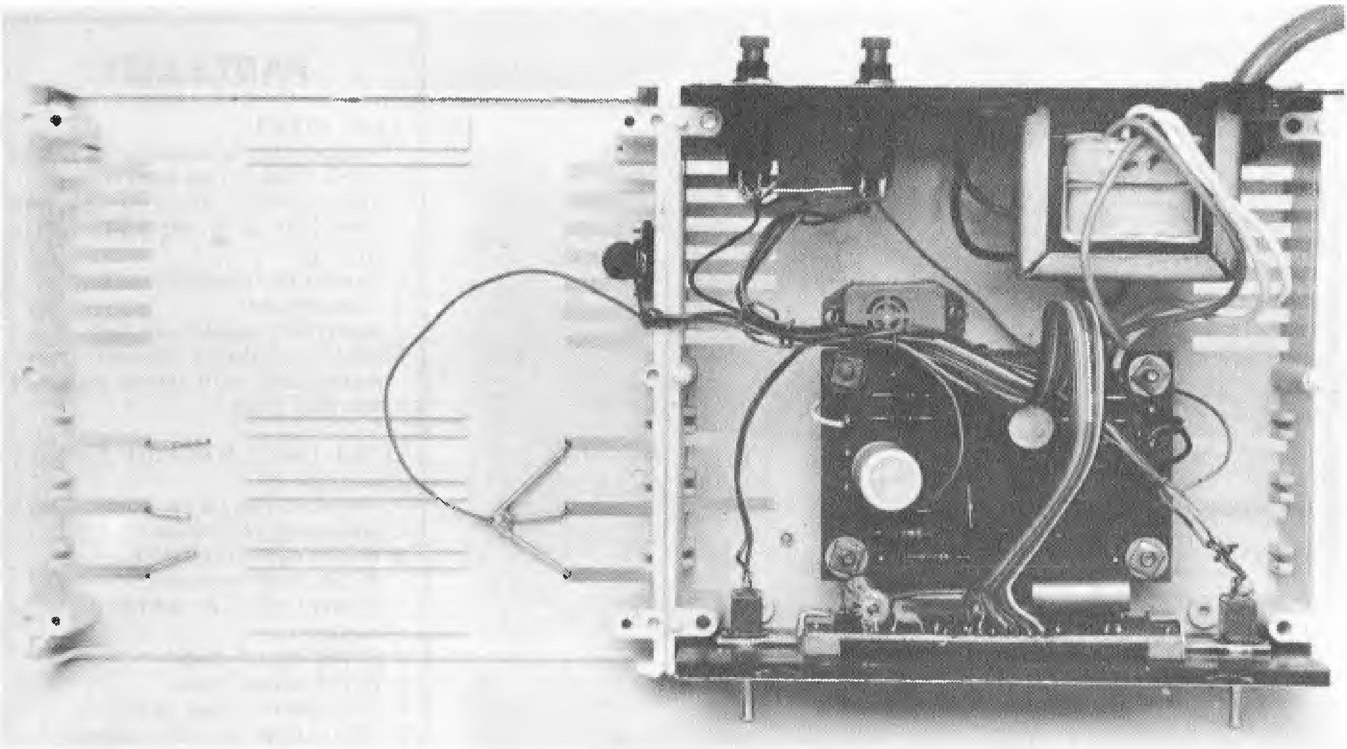
Switch S5 is a single pole toggle switch, and serves to turn the alarm facility on and off. When this switch is in the on position, a small dot in the right hand bottom corner of the display is illuminated.

Switch S6 is a three position toggle switch, with a centre off position. This is used to enable the time setting switches to set the alarm time and the snooze time as well.

Automatic variable intensity of the display can be added quite simply, as shown. All that is required is a 22k trimpot, and an ORP12 LDR (light dependent resistor). These are connected in parallel, and inserted in the link from pad 3 to pad 4.

The next additional feature we have provided is a touch switch to allow convenient activation of the snooze facility. This is based on the Proximity Switch presented on page 94 by fellow staff member Leo Simpson. We have amended his circuit considerably, as our requirements were different, and this has reduced the component count.

Our circuit uses a silicon controlled rectifier (SCR), one BC558 transistor, and four resistors. The cathode of the SCR is connected to one end of the 16V secondary winding via a 6.8k resistor. The anode



is connected to pad 2 of the clock module via a 1k resistor.

Pad 2 is connected to pad E8 by the wiring on the clock PCB, so that an AC waveform is applied across the SCR. When a hand or similar object approaches the touch plate, the increased capacitance triggers the SCR, which then conducts on every alternate half cycle.

The current pulses through the SCR also flow through the 1k resistor, and thus turn the transistor on. The collector of this transistor is connected to the snooze input, pad 8, and thus shorts this pad to pad 2.

Since the transistor is being turned on and off once in every mains cycle, this has the effect of operating the snooze facility at the same rate. This does not affect the snooze operation, but does affect the display.

This is because operation of the snooze switch also changes the display from normal time to the alarm time, so that the display alternates between the two at a 50Hz rate. The visual effect of this is that the two times are combined, producing strange displays like 4 : 98 (from 4 : 46 and 1 : 31).

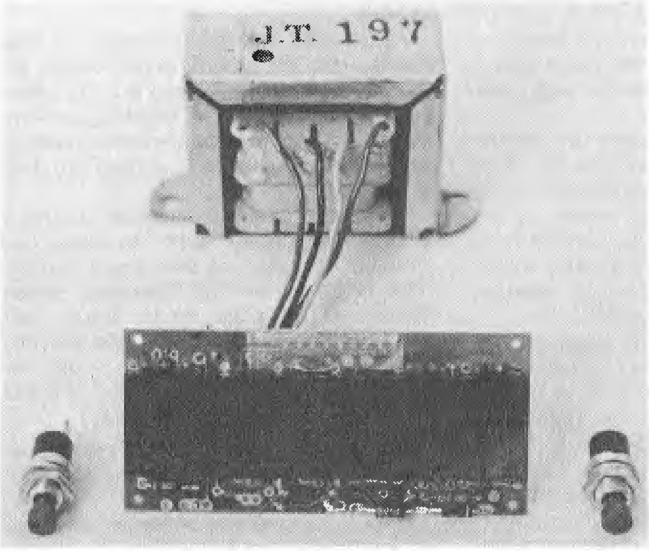
However, as this only occurs for the short time when one's hand is covering the touch plate, we felt that it was not objectionable, and did not warrant extra components to eliminate it.

The remaining features we have added are the alarm and radio drivers. These derive their power supplies from the 10V winding, via two silicon diodes and a 470uF electrolytic capacitor. Each circuit uses a BC548 transistor, to buffer the outputs from the clock module.

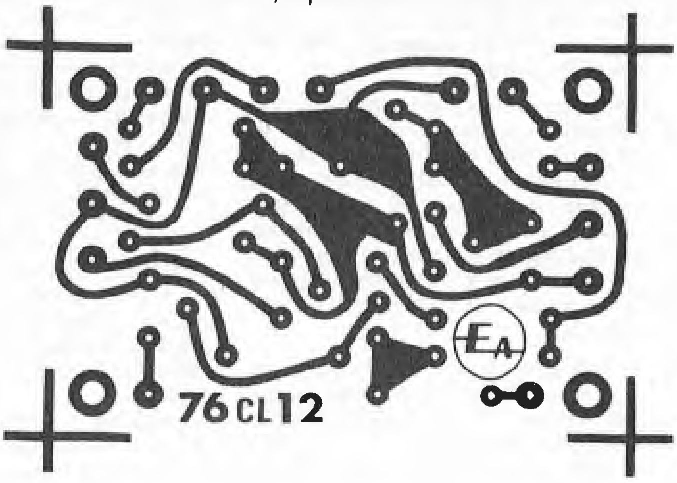
The alarm circuit uses the transistor as a switch, with the load formed by the alarm itself in the collector circuit. The 1N914 diode prevents the base-emitter junction from being reversed biased. The alarm unit can be a solid-state buzzer of the type available from Dick Smith Electronics Pty Ltd, or a Sonalert or similar device. Alternatively, a multivibrator could be used to drive a small speaker.

The important requirements of the alarm unit are that it should operate from a 6V DC supply, and that its current drain should be fairly small, in the order of 20mA or so.

The radio circuit uses a switched regulated power supply to provide a nominal three volts to the radio. This is achieved by using a 3.6V 400mW zener



The photograph at left shows all the components needed to make up the basic clock circuit. Below is the PC board pattern for the full feature clock, reproduced actual size.



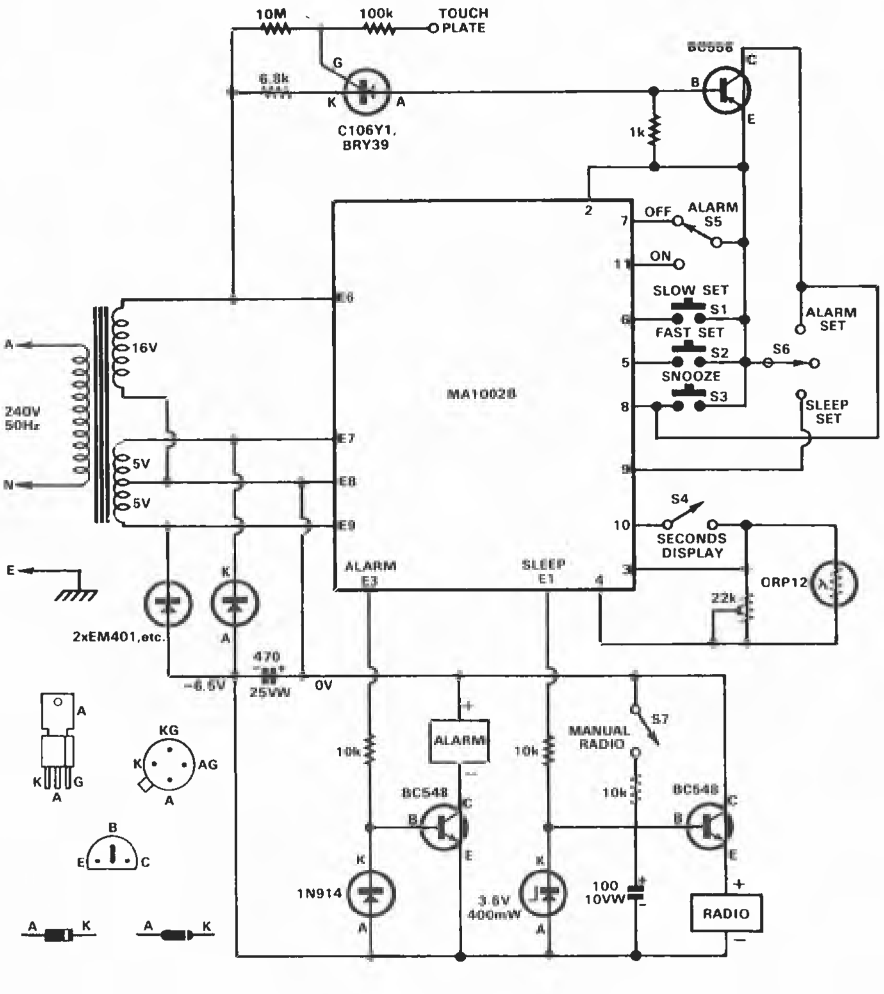


FIG. 3

MODULAR DIGITAL CLOCK

7/CL/

The circuit diagram for the full feature clock. Note that snooze switch S3 is deleted if the optional touch plate circuitry is incorporated.

diode to stabilize the base voltage of the transistor. If higher supply voltages are required, a higher valued zener can be used.

The supply is switched on and off by supplying the zener current directly from the sleep output of the clock module, via a 10k resistor. If a manual switch is required, this can be added by connecting the cathode of the zener diode to the 0V rail (pad E8 or pad 2), via a suitable switch and another 10k resistor.

If a considerably higher supply voltage is required for the radio, say 9V, then it will be necessary to use the 16V winding for this. This will require one extra diode and filter capacitor, which must be connected between pad E6 and pad E8 so as to produce a negative voltage with respect to pad E8.

A 10V zener would then be required, with the anode returned to the new negative rail, along with the negative radio terminal. Note that the current drain which can be taken from this winding is reduced compared to that available from the 10V winding.

Note also that as we have drawn the circuit, the alarm and radio circuits are quite distinct. If it is desired to dispense with the alarm, and use the radio as an alarm as well, then the alarm sections can be left out, and pad E3 connected to the 10k resistor used for the manual radio switch.

Construction of the clock is very easy, and should be within the capabilities of most readers. We used one of the plastic cases from A & R Soanar, measuring 140 x 85 x 130mm. These are of modular construction, and are supplied with a plastic front panel and a metal rear panel. They are available in a variety of colours.

As you can see in the photographs, we mounted the transformer and associated components on the rear panel, and the clock module on the front panel. This was achieved by making a rectangular cutout in the plastic, for the display lens, and pushing the module through from the rear. It is held in place by two small brackets clamped behind the two front panel switches.

Details of the brackets are given in a diagram elsewhere in the article. We used small pieces of foam rubber between the clamps and the module, and between the module and the panel. This gave a firm mounting, without damaging the module.

For the basic clock, all that remains to be completed is the wiring between switches, the module and the transformer. We used small momentary contact pushbutton switches for the basic clock, and completed the wiring with short lengths of colour coded hookup wire.

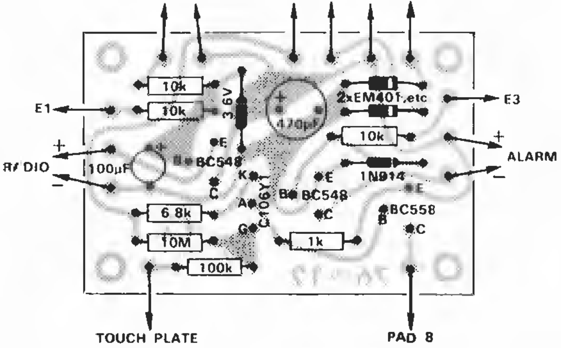
At this stage, it is appropriate to caution readers that some of the pads on the module are connected directly to the clock chip, which is a MOS device, so that caution with regard to static voltages is required during assembly. The module is supplied with a conductive strip joining pads 1 to 11, and this should not be removed till the last moment.

Your soldering iron should be earthed, and connected to the positive side of the 100uF electrolytic capacitor on the rear of the clock board. The wires should be joined to the module by inserting their stepped ends in the relevant holes, and quickly soldered, using a minimum of heat and solder.

Testing simply consists of applying power and checking that the clock operates correctly. When power is first applied, the display should flash at a one second rate. This should stop when either of the time setting switches is operated.

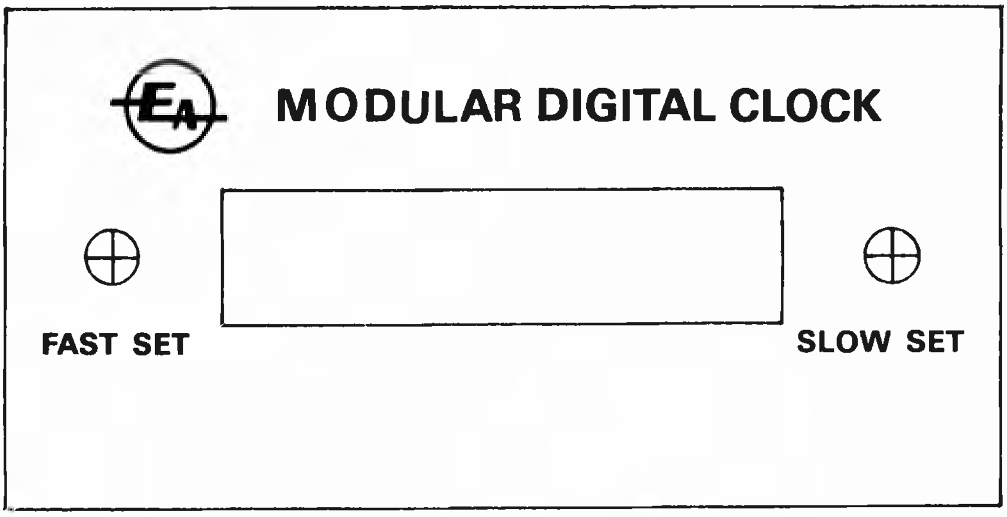
In order to simplify construction of the full feature clock, we have designed a small printed circuit board, coded 76cl12, and measuring 76 x 50mm. This board accommodates the circuitry for the alarm and radio driver circuits, as well as for the touch switch.

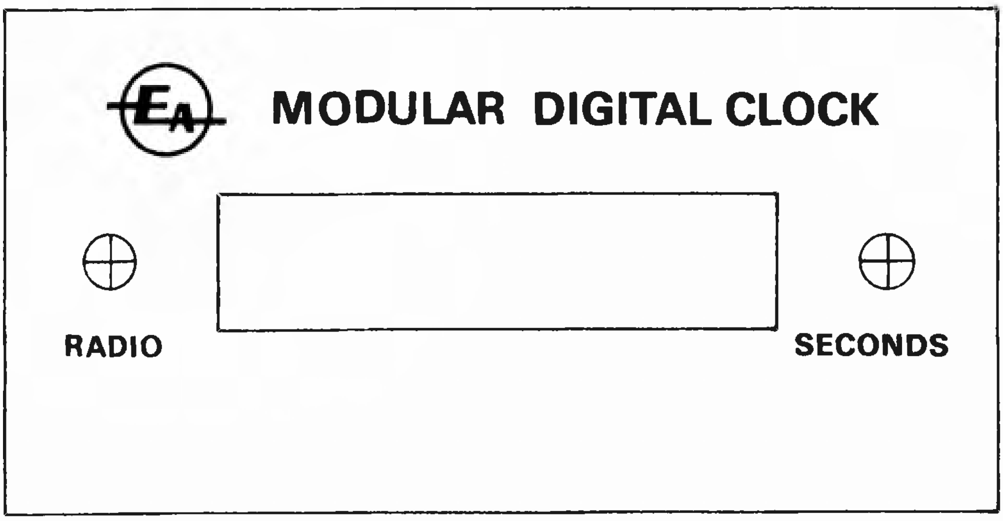
This is mounted on the bottom of the case, using the four corner holes provided, and connected up to the transformer and module with colour coded



Component overlay on the PC board for the feature clock. Use circuit board pins to facilitate external connections.

Right: actual size reproduction of the front panel for the basic clock.





Left: actual size reproduction of the front panel for the feature clock.

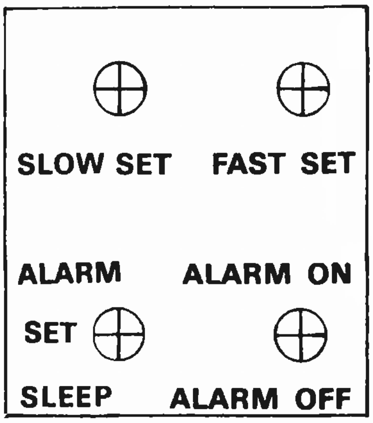
hookup wire. Fourteen external connections to the board are required, and these are best made with circuit board pins.

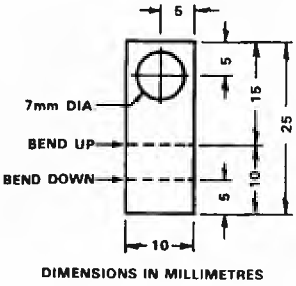
No difficulties should be experienced in placing components on the board. If you are using the BRY39 dual gate SCR, cut off the anode gate (AG) close to the device body, and then treat it as an ordinary SCR.

If you do not wish to add all the features to the clock, simply leave out those components not required. The LDR used to control the display intensity can be glued underneath one of the slots in the top of the case, with the trimpot soldered directly across the leads.

We fashioned a touch plate from three stout pieces of tinned copper wire, fashioned into long staple-like shapes. These were clamped across the case, between the side slots at the front of the case, and bent underneath to hold them in position. At one end, they were bent so as to touch, and the lead to the PCB soldered on. Refer to the accompanying photographs for more details.

We have not shown any mounting details for the radio, as we felt that this was best left up to the individual constructor. One possibility, however, is to simply mount the radio on top of the clock, so that all controls are still accessible.





Above: the metalwork diagram for the two metal brackets. Make two from scrap aluminium. At left is an actual size reproduction of the rear panel labelling (feature clock only).

We have designed two front panels for the clock, one for use with the basic version, and one for use with the more advanced version. Both these are reproduced full size with this article, and they should also be available from the usual metalwork suppliers as well.

We have been advised by National Semiconductor that some of the latest modules which have been imported are supplied without heatsinks on the power transistor. This is no cause for alarm (sorry!) however, as the heatsink is apparently only required in conditions of high ambient temperature and display brightness. If desired, a small heatsink could be fashioned from aluminium, and added to the transistor.

Type B clock modules, transformers and associated parts are available from Radio Despatch Service, 869 George Street, Sydney, and from Techni-Parts, Woolworths Arcade, 95 Latrobe Terrace, Paddington (Qld.) 4064. This latter firm also has type D, F and H modules, in small quantities only, and earphone transducers available.

Control your tape recorder with this

Voice-operated Relay

This is a multi-purpose circuit. It can be used as a voice-operated relay to control a tape recorder, or as a VOX circuit for a transmitter. It can be used with any low impedance or high impedance microphone or a high level source such as a tuner.

by LEO SIMPSON

Quite a few uses can be imagined for this circuit. An obvious use is as a VOX control in a transmitter. It could also be used to control a tape recorder when the material being recorded is of short and spasmodic nature. Another possible use is as a basis for a muting circuit or indeed any sound—controlled function requiring short attack time and slow decay.

The circuit consists of three parts, a microphone preamplifier, a Schmitt trigger and a relay driver. We will start at the left of the circuit and begin with the microphone preamplifier. This is identical to the preamplifiers used in our 8-input mixer of February, March and April 1975 (File 1/MX/10, 11, 12). It is a direct-coupled pair employing two low-noise silicon NPN transistors. Gain is adjustable to suit 600 ohm or 50k dynamic microphones.

There are two feedback loops in the microphone preamplifier. That from the emitter of the second transistor to the base of the first is DC only and sets the DC conditions in the preamp. The second feedback loop is from the collector of the second transistor to the emitter of the first. This is predominantly AC feedback and sets the gain of the preamplifier.

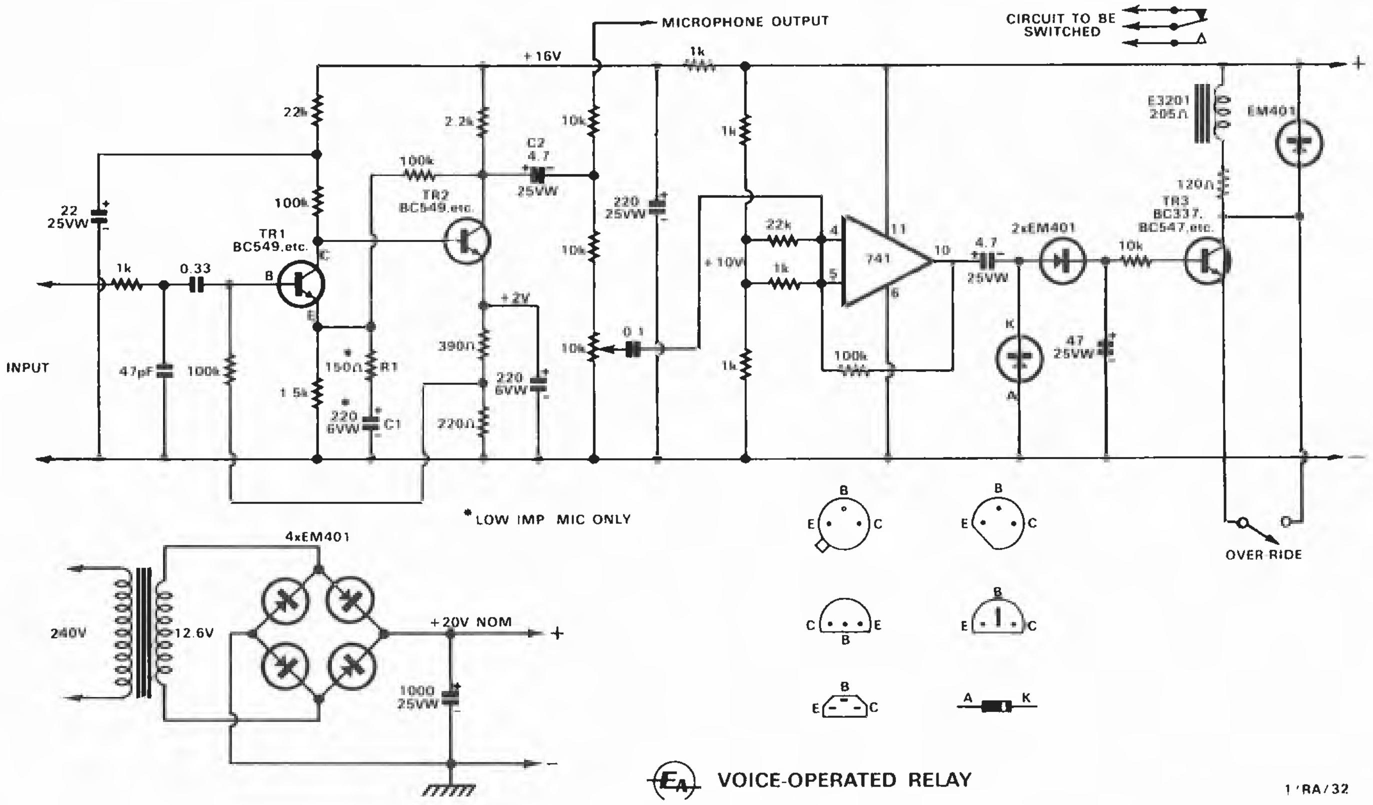
With R1 and C1 included the gain is high enough to suit 600 ohm microphones. In fact it may be too high for some and may have to be reduced. To halve the gain, simply double R1. With R1 and C1 omitted, the gain is sufficient for normal 50k dynamic microphones.

Output signal from the preamplifier is coupled via C2 to a 10k resistor and 10k trimpot which feeds the op amp Schmitt trigger. The microphone output signal is also available via an additional 10k isolating resistor, to drive a high level input on a tape recorder or whatever.

The Schmitt trigger configuration may seem a little unusual at first sight. A voltage divider consisting of two 1k resistors sets the bias for the inverting and non-inverting inputs of the 741 operational amplifier and thus allows it to function with a single rather than the usual balanced supply rails.

Signals from the trimpot are fed to the inverting input. Notice that there is no negative feedback to the inverting input. Instead, there is a positive feedback to the non-inverting input. This has the effect of setting the hysteresis of the Schmitt trigger. For small signals to the inverting input there is no AC output and

This circuit suits 600 ohm or 50k microphones or may be operated from signals of more than 100mV RMS by omitting the preamp.

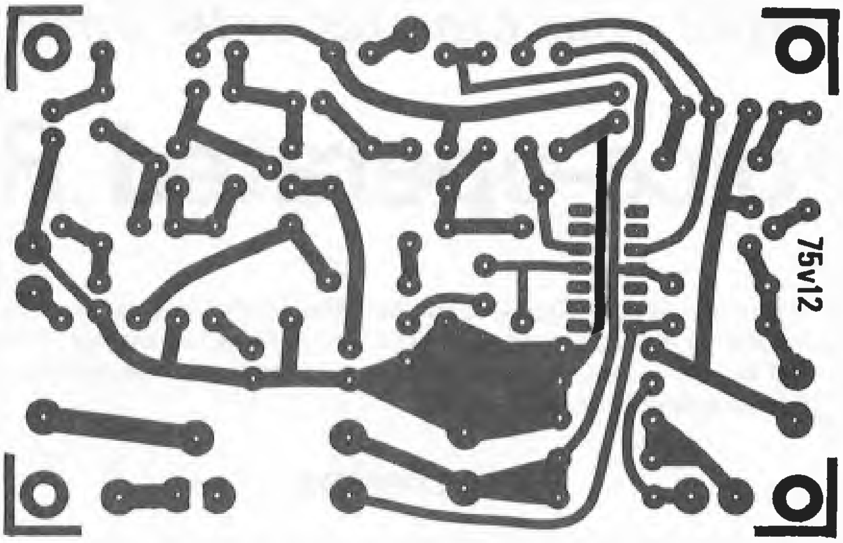


PARTS LIST

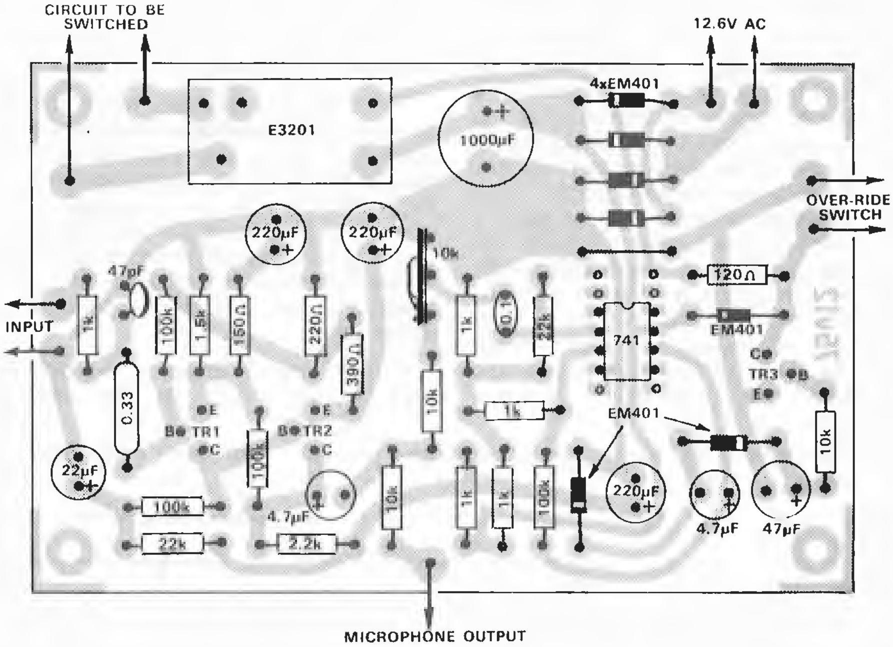
1 PC board, 110 x 70mm, code 75v12
1 miniature power transformer with 12.6VAC secondary, Ferguson PF2851, A&R 6474 or similar
1 SPST switch
2 BC549 NPN silicon transistors
1 BC547, BC337, NPN silicon transistor
1 741 operational amplifier
7 EM401 silicon diodes
1 12V SPDT relay E3201, MD265 or similar
9 PC stakes

CAPACITORS
(all PC end-mounting types)
1 x 1000uF/25VW electrolytic
1 x 220uF/25VW electrolytic
2 x 220uF/6VW electrolytic
1 x 47uF/25VW electrolytic
1 x 22uF/25VW electrolytic
2 x 4.7uF/25VW electrolytic
1 x 0.33uF metallised polyester
1 x 0.1uF metallised polyester
1 x 47uF ceramic.

RESISTORS
(all ¼ or ½W, 5% tolerance)
4 x 100k, 2 x 22k, 3 x 10k, 1 x 2.2k, 1 x 1.5k, 5 x 1k, 1 x 390, 1 x 220, 1 x 150, 1 x 120 ohms.
1 x 10k trimpot
NOTE: Components with higher ratings may be used provided they are physically compatible. Lower rated components may also be used in some cases, provided their ratings are not exceeded.



Here is an actual size reproduction of the PC board.



Layout of components on PC board. Use PC stakes or pins to make connections.

in fact the output terminal is at almost the positive rail potential.

When the signal to the inverting input rises above about 170 millivolts peak-to-peak (which is 60mV RMS for a sine-wave) the output suddenly jumps to the limiting condition which is a square wave at the input frequency with amplitude just a little less than the full supply voltage, ie, about 18 volts peak-to-peak.

So the op amp suddenly changes from a zero gain condition to the limiting condition. This contributes to the fast attack time.

An interesting sidelight to the Schmitt trigger is that it does not revert to the zero gain condition until the signal to the inverting input drops below 20mV RMS (for a sine wave). Output from the Schmitt trigger is fed to a half-wave voltage doubler rectifier which charges a 47uF capacitor. This capacitor (when charged) provides base bias to the relay driver transistor to enable it to energise the relay.

So the overall mode of operation is as follows: Input signals to the microphone preamplifier are amplified and fed to the threshold trimpot. When the selected threshold is exceeded, the output of the Schmitt trigger suddenly rises to 18 volts peak to peak which is rectified and fed to the 47uF capacitor to turn the relay driver on and thereby energise the motor circuit of the tape recorder or whatever device is being controlled.

Attack time of the circuit is inherently limited by the closing time of the relay and this is typically about 10 milliseconds. Delay time after the cessation of input signal is set by the size of the 47uF capacitor to about 3 seconds, which should be ample for most purposes.

Since the relay is a 12V unit, it is fed via a 120 ohm resistor to obtain the correct voltage across it. A diode across the series combination protects the relay driver transistor against inductive kick-back from the relay.

A full-wave bridge rectifier and 1000uF filter capacitor provide the DC rail requirements from any transformer having a 12 to 13VAC secondary winding.

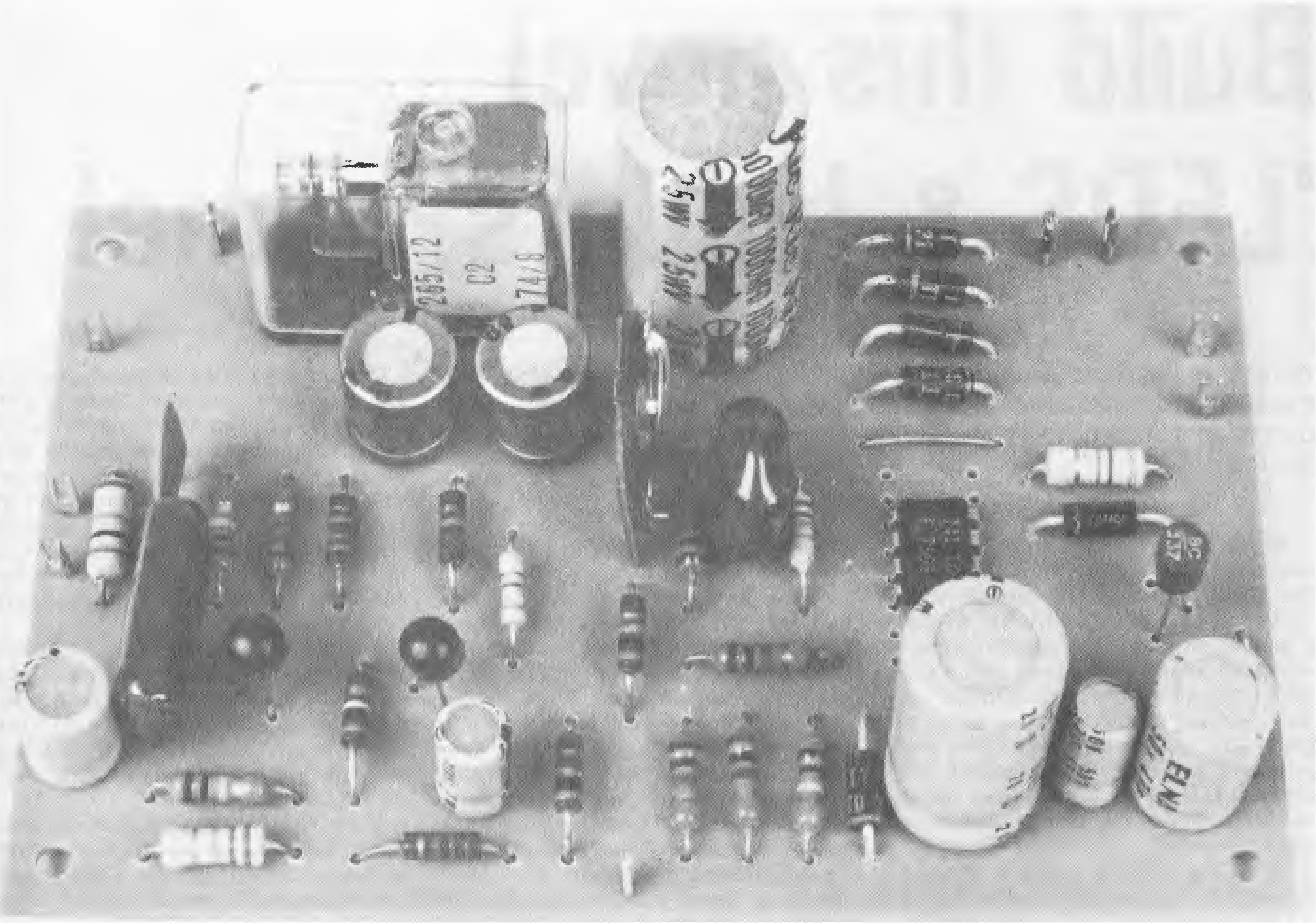
All the components, minus the transformer, are accommodated on a PC board measuring 110 x 70mm with type code 75v12.

The copper pattern of the board is compatible with the three commonly available 741 op amp packages. This is by virtue of the fact that pins 1, 2, 7, 8, 12, 13 and 14 of the 14-lead package have no internal connection while the remaining pins have the same orientation as those of the smaller packages.

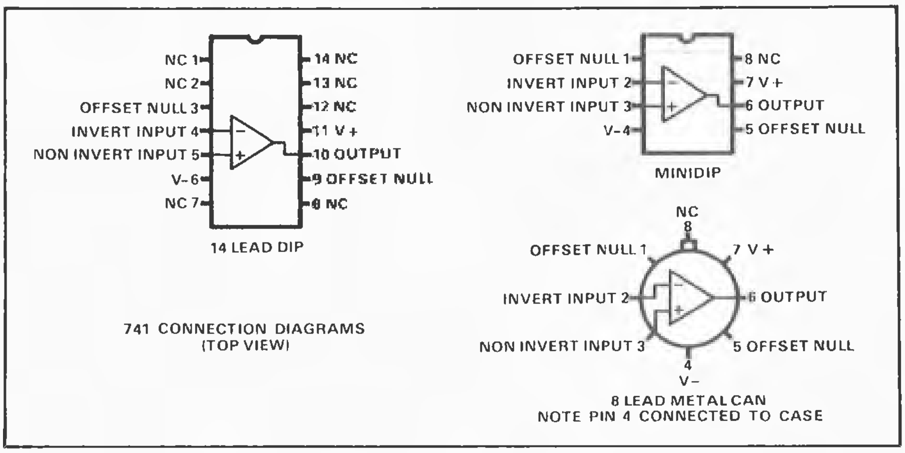
Similarly, while we have specified only BC series TO-92 transistors, the board is compatible with all currently available transistors. Check the transistors you have against the appropriate base diagram on the circuit.

In the interests of uniformity we have specified EM401 silicon diodes throughout. If you have some small signal diodes on hand, they may be pressed into service to rectify the output of the Schmitt trigger.

If you substitute a different relay for



Larger than life size photo of the assembled PC board.



Three different packages of the 741 op amp may be used on the board.

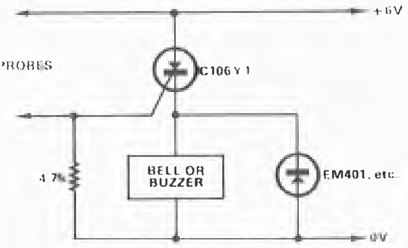
the types we have specified and intend it to switch a 240VAC circuit, make sure it has appropriate contact ratings. The relay we used is soldered directly to the PC board, no socket being used.

If you intend the circuit to be controlled by signals with an amplitude of 100mV or more, the preamplifier stages may be omitted. Just omit all the components to the left of C2. Then substitute a wire link for the 10k resistor between C2 and the trimpot. The input signal is then coupled in via C2. The source impedance of the signal to drive C2 in this way must be less than 5k. The "monitor" output available on many cassette and tape decks is quite suitable for the purpose.

The trimpot may be replaced with a conventional potentiometer as a panel-mounting control, if you so desire.

If the microphone input facility is required, the PC board should be well-shielded or enclosed in a metal box to keep hum and noise to an absolute minimum. The circuit should be grounded only via the microphone input earth return.

Water level alarm



This simple water level alarm was designed for use with a semi-automatic washing machine, but is suitable for other domestic applications. It will sound as soon as water reaches the probe tips.

The alarm will stop automatically as soon as the probe is removed from the water, provided the alarm mechanism employs a constantly make and break arrangement. If not, then an on-off switch or a reset button must be added to the circuit.

The probe used was a 2-pin mains type plug and the battery an Eveready type 509, which should have a very long life. A metal case was used to house the prototype.

(By Mr A. Mann, 6 Jenkins St, Noble Park, Victoria 3174.)

Build this novel 'LEDS & ladders' game!

Here is a low cost pocket-sized electronic game that will test your patience and sense of timing. Seemingly simple, you may find to your dismay that literally hours of practice are required before you can ''reach the top''.

by DAVID EDWARDS

As you can see from the photographs, our new game consists of a small box, fitted with two switches, sixteen small light emitting diodes (LEDs), and an illustrated front panel. The illustration is a schematic drawing of a well, with a ladder reaching from the bottom to the top. The LEDs are arranged on the rungs of the ladder, representing successive foot positions as the ladder is climbed. The topmost LED, which is a different colour to the other ones, is on the ground at the top of the well.

When the POWER switch is pressed, the bottom LED commences to flash at a two second rate. The object of the game is simply to make the LED climb the ladder, by appropriate manipulation of the CLIMB button. Success is signified when the different coloured LED at the top is illuminated.

The trick in the game is that the CLIMB switch can only be operated when a LED is on. When this condition is satisfied the LEDs illuminate in turn, to simulate the effect of a light climbing the ladder.

If, however, the CLIMB switch is pressed when no LED is illuminated, the player is surprised and infuriated to find that when a LED comes on again, he is back at the bottom of the well. Of course, the device is scrupulously fair, so that even if the switch is only pressed for the shortest of times, back to the bottom he goes!

So, having limbered up his wits, as well as his switch operating finger, our player attacks the infernal machine again. With his eye glued to that first LED, and his finger poised, he waits for that light to come on. Flash!, the LED emits, his finger stabs the button, and the LED commences to climb!

One! two! three! four LEDs emit in turn, the button is released, and a fraction of a second later, the LED goes out. With bated breath, our player scans the LEDs, and is rewarded by seeing the fourth LED come on again. Once more he stabs at the button, once again the LED commences to climb.

Some time later, the fifteenth LED casts a ruddy glow over the perspiring face of our player, who decides to stop for a short time to wipe his brow. Those last few steps had seemed to be harder to climb than the earlier ones, in fact, he'd only just managed to go from the fourteenth to the fifteenth rung in one go.

Directing his attention back to the game, our hero is horrified to find that he's slipping back down the ladder, now only the fourteenth LED is alight. Desperately, he punches mindlessly at the button, the LED climbs up higher, just reaches the top, and then goes out. And he's still pressing the switch!

With a heart-rending groan, he releases it, and then watches dejectedly as the lowest LED flashes merrily. Some minutes later, he musters his courage, and once more commences to climb.

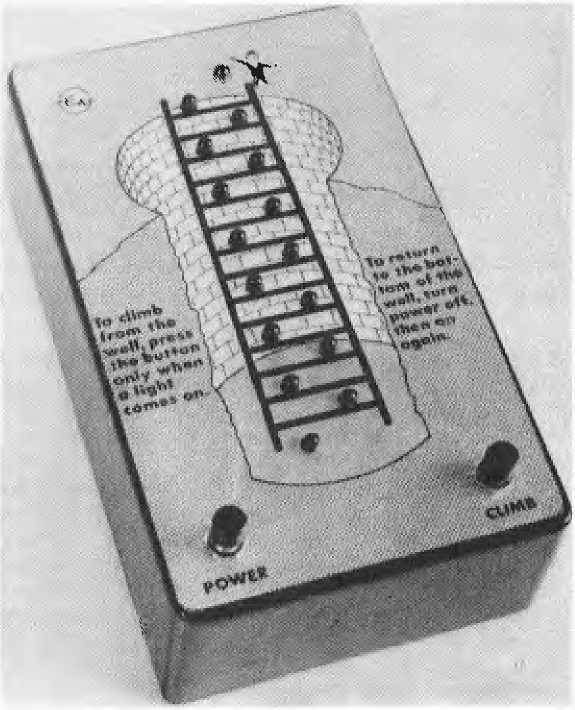
Just in case you're wondering whether or not it is possible to reach the top, we can assure you that it is. In fact, the little man at the top is waving to show you that he managed it, so don't lose heart and give up.

Turning now to the circuit diagram, we can examine its various sections, and see exactly how the game operates. The 555 type IC functions as an astable multivibrator. The frequency of operation is determined by the two 100k resistors and the 10uF capacitor. The diode connected between pins 6 and 7 serves to make the mark/space ratio unity, while the 0.01uF capacitor connected to pin 5 ensures reliable triggering.

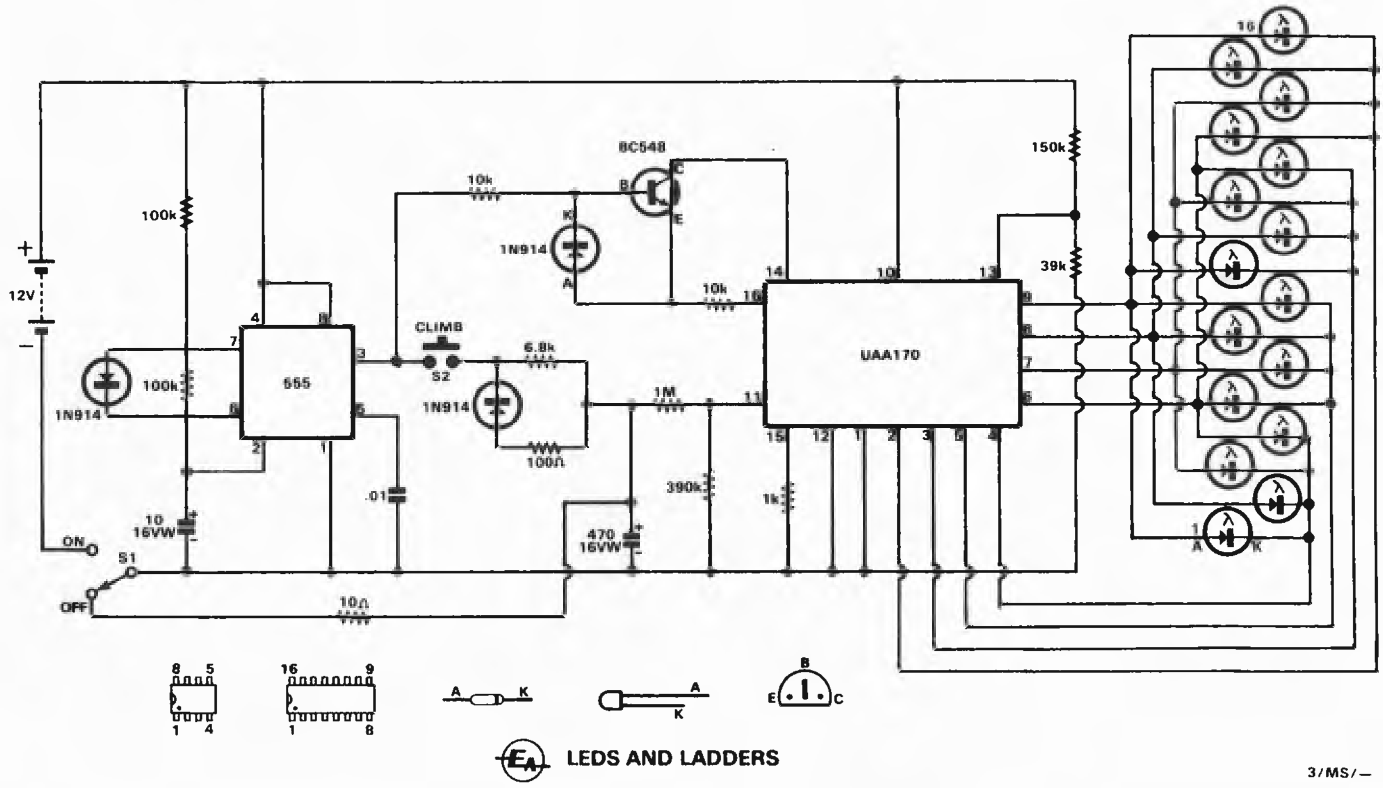
The output from the timer is obtained at pin 3, and is in the form of a squarewave with an amplitude only slightly less than the supply voltage. The CLIMB push-button connects this pin to a large electrolytic capacitor, via a diode/resistor network.

If the CLIMB button is pressed when the voltage on pin 3 is high, the diode is reverse-biased, and the 470uF capacitor is charged via the 6.8k resistor. When the button is released, the capacitor commences to discharge through the 1M and 390k resistors. However, the time-constant is very long, of the order of 10 minutes, so that for the moment we will assume that the capacitor retains its charge indefinitely.

However, if the CLIMB button is pressed when the voltage on pin 3 is low, the diode is forward biased, and the capaci-


EA
To climb from the well, press the button only when a light comes on.
To return to the bottom of the well, turn power off, then on again.
POWER
CLIMB

You can see from this illustration how we have arranged the LEDs on the ladder rungs. The one at the top is a different colour, to signify success. Instructions detailing how to play are included on the front panel.



The complete circuit diagram for the game. The LED numbered 1 is placed at the foot of the ladder, and the one numbered 16 at the top.

tor discharges rapidly through the 100 ohm resistor. Thus the capacitor voltage represents the distance up the ladder that the operator has climbed.

Since the capacitor is charged from a constant voltage, the voltage across the capacitor follows an exponential law with respect to time. This means that the initial rate of change of voltage is much higher than the rate towards the end of the charging period.

Thus a given closure time of the CLIMB switch will propel the "player" quite a few rungs up the ladder if he is near the bottom, but only one rung or less if he is near the top. This is why our hypothetical player found the going harder at the top of the ladder.

A second feature arising from this exponential curve is that the rate of discharge is greatest at the top of the ladder, so that an error in timing there produces a greater fall down the ladder than a corresponding mistake at the bottom. Now you can begin to see why the game is so infuriating

The power switch is placed in the negative supply line, and is a changeover type. This is so it can be used to discharge the 470uF capacitor, through a 10 ohm limiting resistor, when the power is turned off.

We can now turn to the second section of the circuit. This is the conversion from the capacitor voltage to the LED display. The heart of this is the new UAA170 IC, a 16 pin DIL plastic encapsulated device distributed in Australia by Siemens Industries Limited, who have offices in all major states. Order it from them via your usual supplier.

Internally, the UAA170 consists of a set of fifteen comparators. These compare the input voltage with a proportion of the supply voltage, and hence drive 16 LEDs. A matrix encoding scheme is used to reduce the number of connections required for the LEDs from 32 to 8. A zener diode is used to generate a stable voltage for powering the LEDs, so that their brightness is independent of the supply voltage.

By varying a single resistor, it is possible to vary the LED current over a wide range. The comparator and encoding network is arranged so that each LED is illuminated in turn, so that when they are arranged in a line, the effect is of a point of light moving along the line. It is possible to adjust the transition between LEDs to be either abrupt or gentle.

All this is contained in a single 16 pin IC, whose current consumption is typically 4mA (neglecting the LED current). The maximum LED current available is 50mA.

Pins 12 and 13 are the reference inputs to the comparators. The voltage applied to pin 12 becomes the lower threshold, while the voltage applied to pin 13 becomes the upper threshold. We have grounded pin 12, so that the first LED will turn off when the voltage applied to the control input goes slightly positive.

The sixteenth LED will be illuminated when the voltage on the control input exceeds the voltage on pin 13, while for voltages in between these two extremes, corresponding LEDs will be illuminated. Note that when the threshold between two LEDs is being crossed, both LEDs will be partially illuminated.

The control voltage is applied to pin 11 from the voltage divider formed by the 1M and 390k resistors. These values have been chosen in conjunction with the values for the divider connected to pin 13 to ensure that it is possible to turn on the sixteenth LED.

(over)

PARTS LIST

1 555 timer IC
1 UAA170 LED driver IC
1 BC548 NPN transistor, or equivalent
3 1N914 or 1N4148 silicon diodes
16 small LEDs
1 470uF 16VW PCB mounting electrolytic capacitor
1 10uF 16VW PCB mounting electrolytic capacitor
1 0.01uF plastic capacitor
1 1M, 1 390k, 1 150k, 2 100k, 139k, 2 10k, 1 6.8k, 1 1k, 1 100ohm & 1 10ohm ¼W resistors
1 N/O push-button switch
1 single pole changeover switch, push-on, push-off
8 1.5V penlight cells
2 holders to suit
2 battery clips to suit
1 printed circuit board, 71 x 71mm, coded 76g3
1 plastic case, 159 x 96 x 50mm
MISCELLANEOUS
Rainbow cable, solder, machine screws, nuts, washers, scrap aluminium, foam rubber, PCB stakes

LEDS & LADDERS

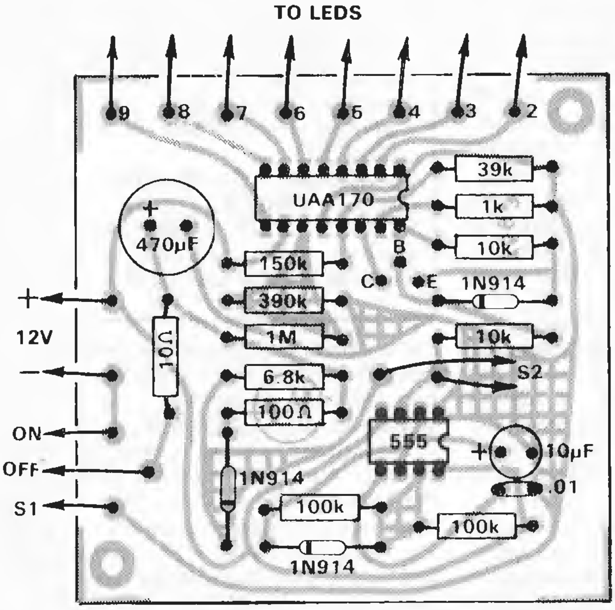
Although we stated earlier that the loading on the 470uF capacitor was negligible, this is not strictly so. The 1M and 390k resistors, in conjunction with the impedance presented by pin 11, as well as the leakage resistance of the electrolytic itself, combine to slowly discharge the capacitor. This discharge is most noticeable when the capacitor is highly charged, and accounts for the "slipping back" observed by our hypothetical player. This effect adds to the difficulty of the game.

The stabilised LED driving voltage is made available at pin 14, and is normally connected to pin 16 by a suitable resistor. We have included a transistor in series with a 10k resistor, and used the output of the 555 to switch the transistor on and off. This pulses the LEDs, eliminating the need for a separate flashing indicator.

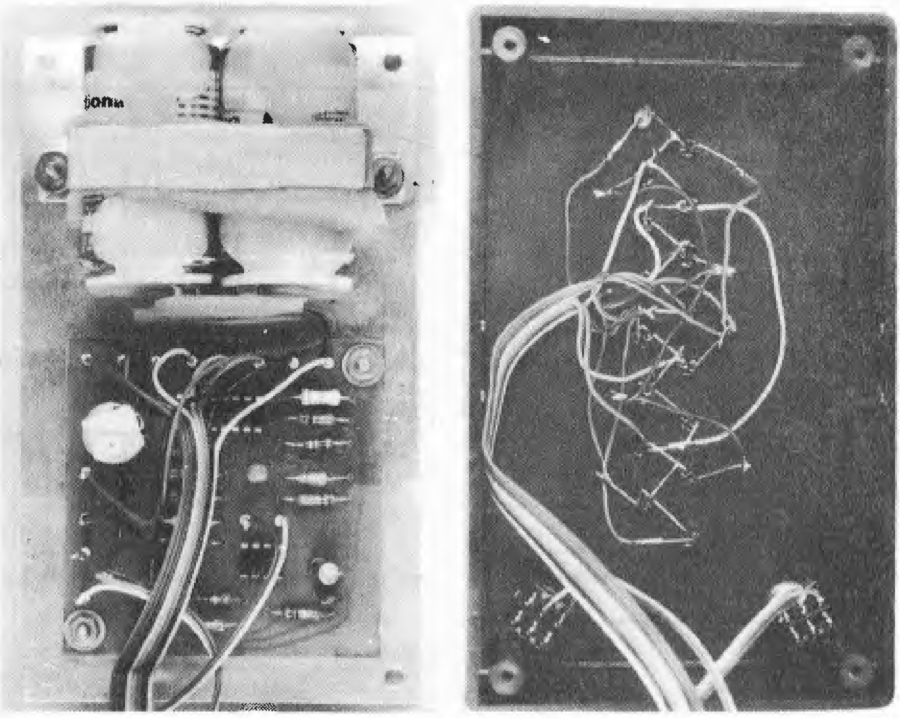
As well as being economical in terms of components, this also means that a stabilised supply is not necessary. This is because the 555 and the UAA170 both use fractions of the supply voltage as their references, making frequency and comparator switching levels independent of supply variations. As the LEDs are driven from a constant voltage source, their intensity does not change with supply voltage either.

We have used eight 1.5V penlight cells to power the circuit, giving a nominal 12V supply. The batteries are mounted in two 4-way holders, as shown in the photographs. The average current drain of the complete circuit is about 25mA, giving an estimated life of 40 hours.

If required, it would be possible to fit a small transformer and rectifier/filter assembly in place of the batteries, although the initial cost would be much higher. The voltage applied to the circuit must be kept below 16V, to prevent damage to the ICs.



The numbered connections at the top correspond to the pin numbers of the UAA170. Refer to the main circuit diagram for details of the wiring required to the LEDs.



These two photographs give a clear picture of the internal construction, including details of how the LEDs are wired together.

Construction of the game is quite simple, as all major components except the LEDs are mounted on a printed circuit board (PCB). This measures 71 x 71 mm, and is coded 76g3. We recommend the use of PCB stakes for all external connections to the PCB. Fifteen are required.

We mounted the game in a standard plastic utility box, measuring 159 x 96 x 50mm, fitted with an aluminium lid. We used the box upside down, which necessitated filing off the moulded-in feet on the bottom. We made a front panel from photo-sensitive aluminium, and used this as a template for drilling the required holes for the LEDs and switches.

We expect that component suppliers will be able to supply suitable front panels. Alternatively, dyeline prints are available from our Information Service. These may be used to make bromide prints by the contact method.

The LEDs are simply pushed into suitable holes. If necessary, mounting clips can be used, or they may be simply glued in position. Arrange them so that the anodes and cathodes are all oriented in similar fashion, as this will facilitate wiring them up. If desired, the top LED can be a different colour, to signify success.

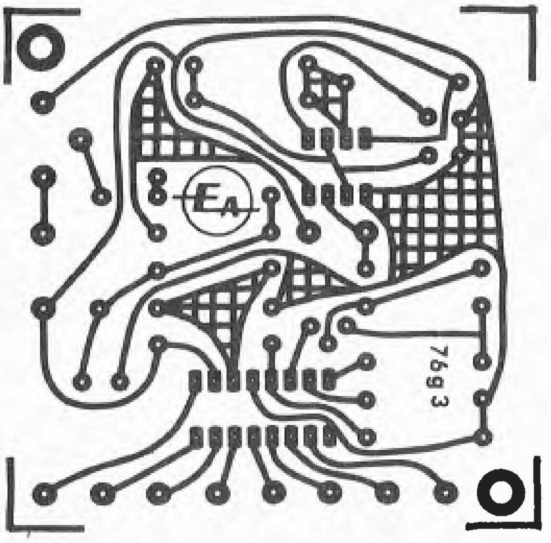
The choice of the switches poses a slight problem. Matching push-operated switches, such as we used, are obtainable, although they are expensive. If required, non-matching switches could be used, e.g., a slider type for the power switch, and an economy push-button for the climb switch.

The completed circuit board is fastened to the lid of the box using machine screws and nuts. The batteries are held in position with a small clamp fashioned from aluminium.

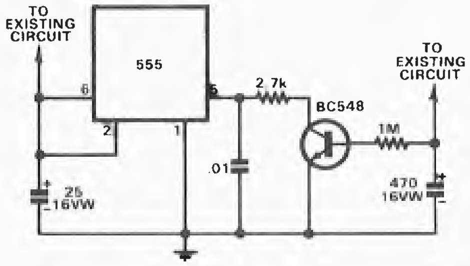
The wiring from the PCB to the LEDs and switches is best done with rainbow cable, as this makes for easy identification of the different leads. Complete the interconnections between the LEDs first, using the circuit diagram as a guide, and then connect them to the PCB.

Construction is then complete, and you can attempt to climb the ladder. If the LEDs do not come on in order, it is likely that the connections to them are in error. Any LEDs failing to emit will probably have anode and cathode transposed.

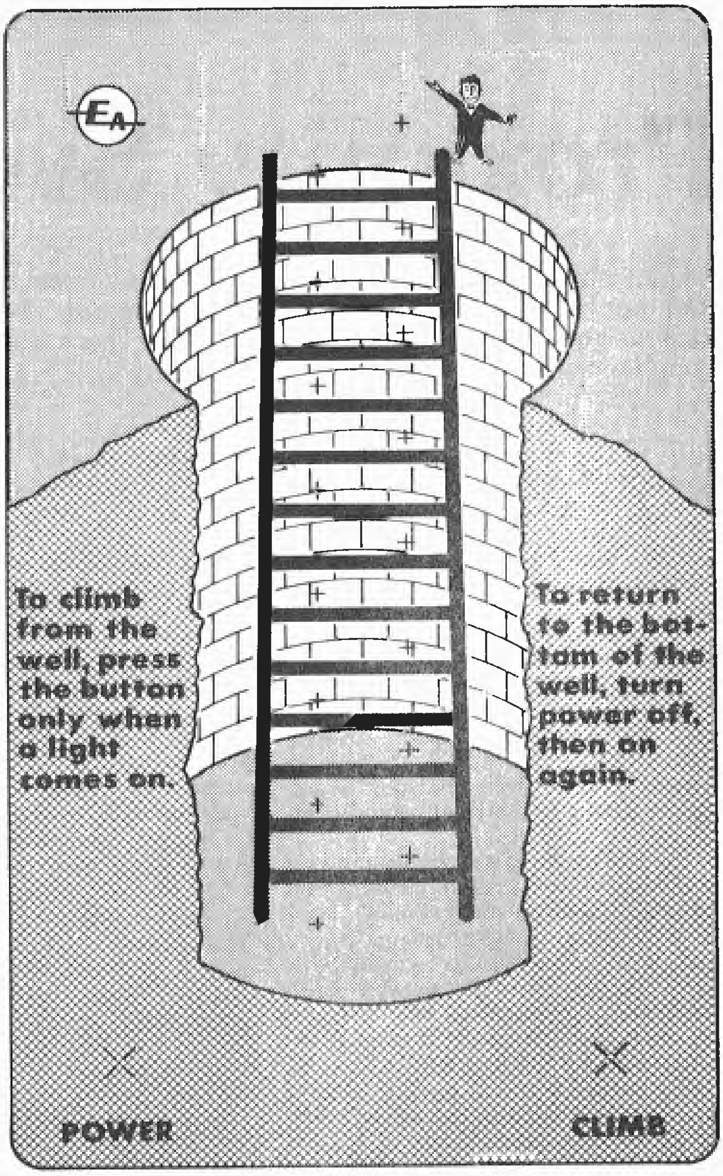
Once you have mastered the necessary skills, and can climb to the top of



Shown above is the PCB pattern, while to the right is a reproduction of the front panel. These are both full size, and can be copied if desired.



A simple modification to the game, as shown above, can make it very much harder to reach the top of the ladder.


To climb from the well, press the button only when a light comes on.
To return to the bottom of the well, turn power off, then on again.
POWER
CLIMB

the ladder in a dozen or so steps, a small modification can be made to make the game even harder to beat. By adding a single transistor and two resistors, the circuit can be modified so that the flashing rate becomes dependent on the amount of charge in the 470uF capacitor.

The accompanying diagram shows how this is done. The BC548 transistor is used as a variable resistance, loading down the control input of the 555 timer. As the voltage on the 470uF capacitor rises, the bass current in the transistor increases, turning on the transistor.

This loads down pin 5, and changes the internal thresholds, so that the timing capacitor does not have to charge and discharge through the same voltage swing. This speeds the oscillator up, while maintaining the mark/space ratio at approximately unity.

Thus the LEDs turn on for shorter and shorter periods, making the task of climbing to the top of the ladder harder and harder as the climber approaches the top. The 1M base resistor serves to keep the transistor on the linear portion of its operating curve, while at the same time minimising loading.

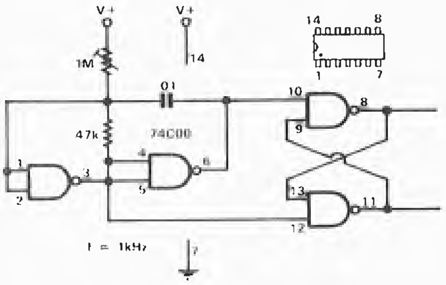
The 2.7k resistor limits the maximum frequency of the 555. This value can be varied if required. With the value we have shown, we found that at the top of the ladder, the "on" pulses were a little too short for satisfactory operation, so we changed the 10uF timing capacitor to 25uF. This gave an acceptably wide "on" pulse, while still making the task of climbing the ladder suitably difficult.

No provision has been made on the PCB for these components. However, with a little care and ingenuity, they can be fitted to the pattern underneath the board. We will leave the exact details of this to individual constructors.

2-phase CMOS clock oscillator

Here is a simple oscillator, based on a CMOS quad gate. The first two sections are wired as inverters, and connected to form an RC oscillator. With the values as shown, the frequency is approximately 1kHz. The waveforms at pins 3 and 6 are somewhat rounded complementary square waves. If required, a 1M trimpot can be connected between the positive supply rail and pins 1 and 2. This can then be adjusted to give a unity mark/space ratio.

The remaining two gates are used as a flip-flop, to "square up" the waveform. The rise and fall times are less than 1us.



The oscillator will operate with supply voltages between about 3V and 15V, with some variation in frequency.

Make a novel door chime with a simple

Proximity Switch

Using only three low cost semiconductors, this simple project will have sure appeal to beginners and old hands alike. Just bring your hand close to the sensor plate, and the circuit will cause a lamp to light or sound a buzzer.

by LEO SIMPSON

The simple proximity switch to be described here has several intriguing uses around the home. It also has possible application in the retail trade, for sales promotions.

Around the home, it may be used as a novel door chime unit, or as a "surprise" gimmick for parties. Imagine the fun if a bell were to ring whenever a guest reaches into the bowl of sweets, or sits down in that unoccupied armchair!

Some of the ideas for sales promotions could be as follows. A sensor plate could be placed behind a shop window. Window shoppers could then trigger the circuit. It might be used to turn on lights over display stands, actuate a slide projector or an endless loop cassette player. It could also be used as an attention alarm on shop counters. In fact, this unit is almost identical to that used on the counter of the former editorial office of "Electronics Australia".

An alternative use on a counter or display stand would be to actuate warning signs. A sign reading "Please do not touch" could thus light up or sound a buzzer when a person disobeyed. Museums could use this device by the dozen!

Total cost of the project is very low at $15 or less, including all hardware and metalwork.

The circuit is very similar to that featured in June 1971 of "Electronics Australia" (File No 2/MS/21). The major difference is that the new circuit employs a lower voltage transformer, which is considerably cheaper and more readily available. As a result the new circuit may not be as sensitive as the original, but it should still be quite sensitive enough for all likely applications.

The semiconductors complement is two SCR devices and one zener diode. Before describing the circuit operation, let us describe the behaviour of these three devices.

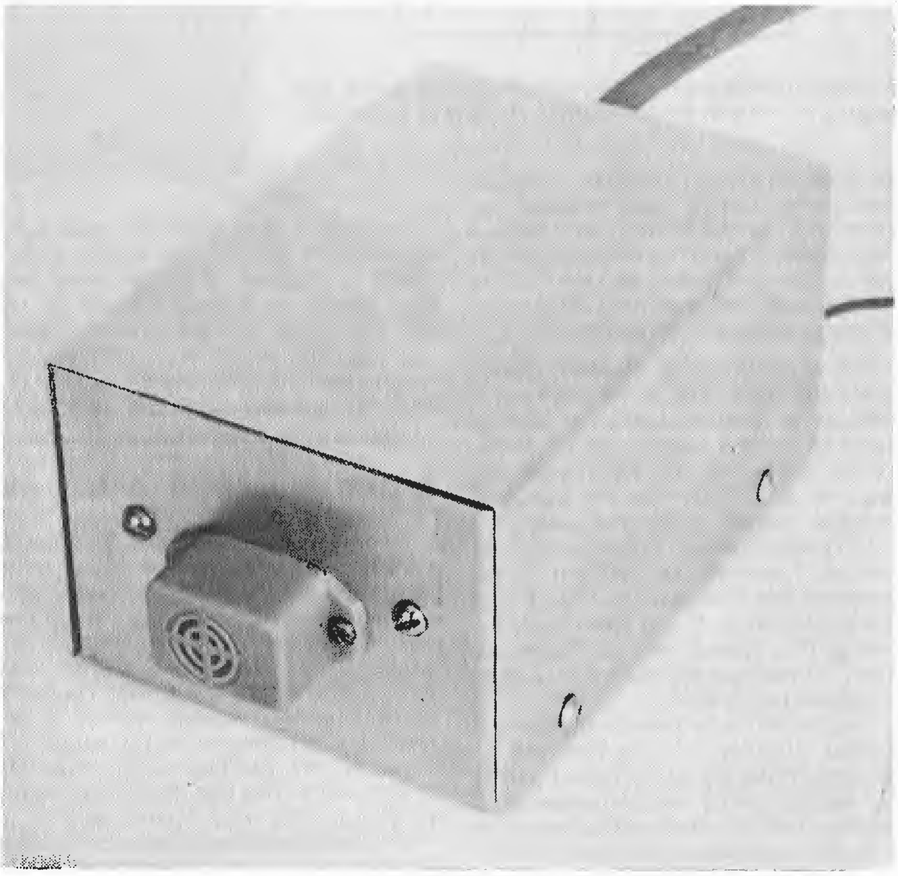
A zener diode can be regarded as a normal diode with a safe reverse breakdown characteristic. With voltage applied in the forward direction, it has a conduction voltage of around 0.6V or more, just like any silicon diode. With voltage applied in the reverse direction, the zener is non-conducting up to a specified voltage. Exceeding this voltage by a small margin causes reverse breakdown with a low dynamic resistance. Limiting resistors must be placed in the circuit to prevent over dissipation in the diode.

Conventional uses of the zener diode are voltage limiting (or waveform clipping) and in regulated voltage sources.

The two SCR devices are a conventional SCR and a complementary or "anode gate" SCR (also known as a programmable unijunction transistor). An alternative device to the complementary SCR is the silicon controlled switch or SCS.

The SCR is one of the family of semiconductor devices known as thyristors. It can be regarded as a special type of recitifier diode which conducts in one direction only. What sets it apart from a normal diode is that when it is forward-baised, it will not conduct until it is triggered into doing so by a small positive voltage applied between its third "gate" electrode and the cathode. With a sine wave voltage applied between anode and cathode, an SCR can be triggered into conduction at any instant during the positive half-cycles. At the end of each positive half-cycle, the SCR turns off as the voltage polarity reverses.

The complementary SCR, is very similar to an SCR, except that it has a gate electrode which is associated with the anode rather than with the cathode. The silicon controlled switch or SCS is virtually a combination of the two, having both an "anode gate" and a "cathode



Housed in an aluminium box, the prototype Proximity Switch drives a small buzzer.

gate". Either can initiate conduction.

Referring now to the circuit diagram, a power transformer with a centre-tapped 12.6V secondary winding is required. The complementary SCR is connected across the whole winding, in series with 6.8k and 1k resistors. The cathode side of the winding is connected to earth (chassis). Note that when an SCS is used, the cathode gate is not connected.

Now for the complementary SCR to switch on during positive half-cycles of the AC waveform, the anode gate must be made negative with respect to the anode. If a person touches or brings their hand close to the sensor plate which is connected to the gate via the look resistor, triggering occurs because of the increase in capacitance between the gate and earth. The increase in capacitance causes the phase lag of the sinusoidal voltage appearing at the gate to increase with respect to the voltage at the anode, until the voltage difference between the anode and anode gate is sufficient to cause triggering.

Because a zener diode with a 10V rating is connected from the anode of the complementary SCR to earth, the voltage appearing at the anode is a clipped, half-wave rectified sine wave with a peak amplitude of 10V.

This means that the phase shift between anode and anode-gate voltages can only cause the anode gate voltage to drop below the anode during that period in the half-cycle before the zener diode begins to clip the waveform. Once the voltage at the anode is limited to 10 volts, there is little chance of the anode gate voltage being reduced below this figure.

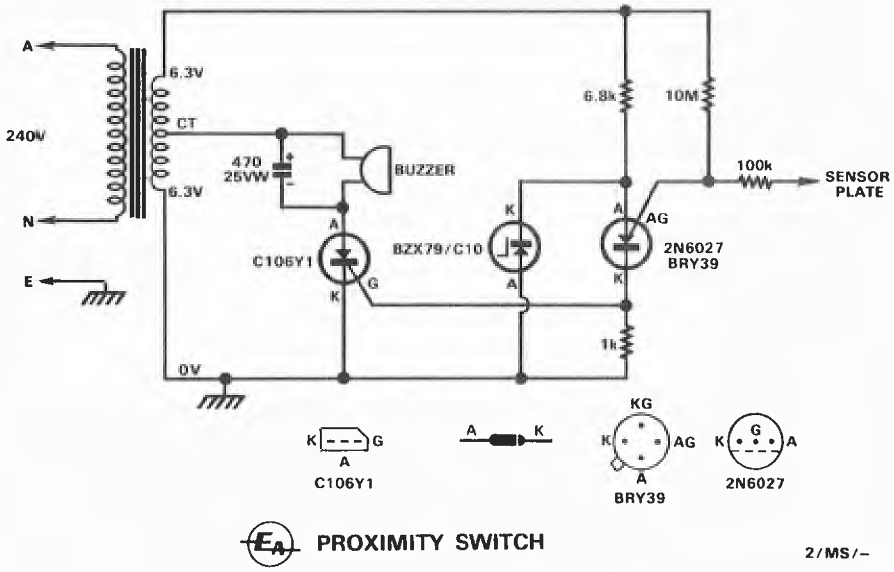
So because of the zener diode, triggering produced by gate circuit capacitance always tends to occur early in positive half cycle, giving the circuit an all-or-nothing switching characteristic.

When the complementary SCR fires, it applies a proportion of the zener-diode-clipped voltage across the 1k resistor. This, in turn, forward biases the gate of the SCR to trigger it into conduction.

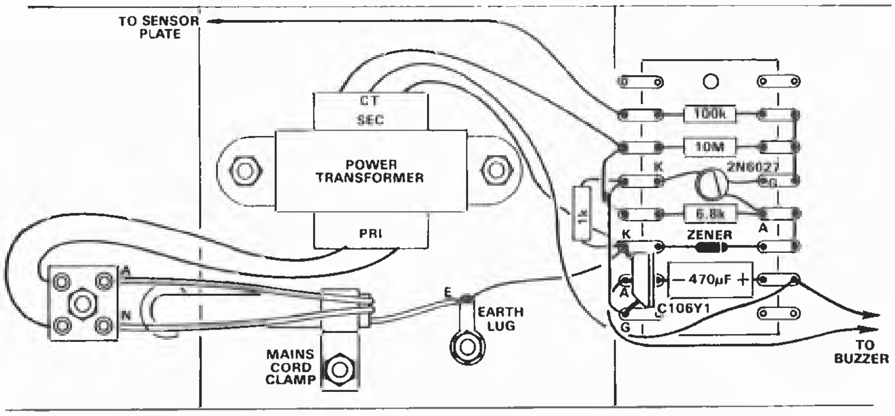
Since the SCR rectifies the 50Hz sine applied to it, the voltage applied to the SCR load needs to be filtered to obtain DC. This is achieved by the 470uF capacitor across the load.

An interesting feature of the circuit now becomes apparent. Normally, an SCR in a circuit such as this would be capable of varying the power to the load. However, since the rectified AC to the load is filtered and since the circuit triggering can only occur early in each positive half cycle, the load voltage is essentially independent of sensor capacitance, once it is sufficient to cause triggering.

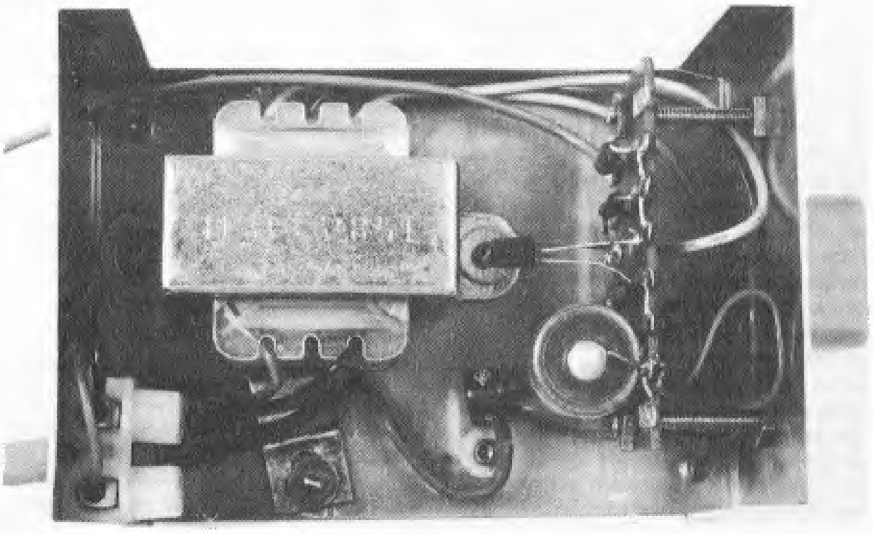
If the zener diode was not included in the triggering circuit, both the complementary SCR and the conventional SCR could be triggered at any instant during the positive half-cycles of the 50Hz AC input. This would mean that the capacitance of the sensor plate could vary the DC voltage applied to the load—giving rather erratic operation.



Only three economy semiconductors are used in this simple circuit.



This diagram and the photo below show how to assemble the unit.



The load used in our prototype is a neat little solid-state buzzer available from Dick Smith Electronics Pty Ltd. It is considerably cheaper than a Sonalert although it is not as loud. The load could alternatively be a small relay.

Construction of the proximity switch is straightforward and non-critical in terms

PROXIMITY SWITCH

of layout. We housed the prototype in a compact aluminium mini-box measuring 104 x 74 x 53 mm.

Since the circuit and the suggested buzzer have a current drain of less than 20 milliamps, almost any 12.6V transformer may be pressed into service. We used a small 2.5VA type, DSE 2851, supplied by Dick Smith Electronics Pty Ltd. Equivalent types are Ferguson PF 2851 and A & R 6474. If buzzers with higher current than about 150mA are used a higher rated transformer will be required. Maximum rating of the SCR specified in the half-wave mode is about 700 milliamps. (No heatsink and at room temperatures).

If the load current is more than about 50 milliamps, the filter capacitor will have be increased accordingly, to obtain satisfactory operation.

This is the buzzer, twice actual size.

All the small circuit components are mounted on an eight-lug length of miniature tagboard. The SCR is soldered directly into circuit and no heatsink is required. If an SCS such as the BRY39 is used, the cathode lead can be clipped short or sleeved to prevent it touching other components and possibly prejudicing the circuit operation.

The buzzer may be attached to the case by small self-tapping screws, or with epoxy adhesive.

Note that the case and circuit must be earthed via the mains cord, otherwise the device will not work. The lead to the sensor plate runs out via small hole in the case. Shielded cable must not be used, otherwise cable capacitance may turn the unit on continuously. Nor should the sensor lead be too long, otherwise stray capacitance will be too high.

The three-core mains cord should be passed through a grommetted hole in the end of the case and anchored with a cord clamp. Terminate the earth conductor to a solder lug on the case. Terminate the active and neutral conductors to a two-way insulated terminal block. Connections to the transformer primary are then made via the terminal block.

A sensitivity control may be added by connecting a 5 megohm pot, wired as a variable resistance, in series with the sensor lead. This will serve to make the unit less sensitive, if need be.

When the unit is complete and ready for installation choose a location which requires a minimum length of lead to the sensor plate. The sensor plate should be kept reasonably far away from earthed metal objects (30cm should be adequate) otherwise sensitivity may be compromised. The sensor plate may be concealed or visible, but it should be at least as large as a male hand (say 150 x 200mm).

Note that the sensor plate may be touched directly. There is no danger of electric shock, due to the low circuit voltage and high values of resistance in the sensor circuit.

PROXIMITY SWITCH PARTS LIST

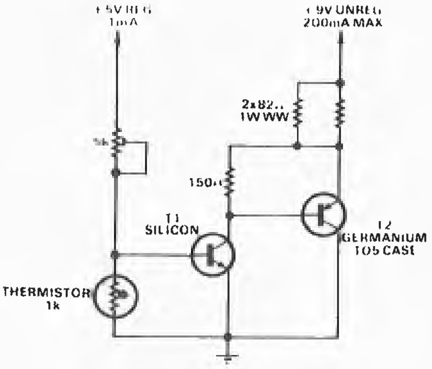
1 aluminium mini-box, 104 x 74 x 53mm
1 9V buzzer (available from Dick Smith Electronics Pty Ltd)
1 C106Y1 SCR
1 2N6027 complementary SCR (or PUT) or BRY39 SCS
1 BZX79/C10 zener diode
1 470uF/25VW pigtail electrolytic capacitor
1 x 10M, 1 x 100k, 1 x 6.8k, 1 x 1k (¼ or ½W resistors).
1 2-way insulated terminal strip
1 solder lug
1 cable clamp
1 grommet

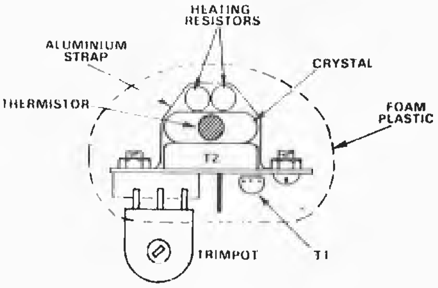
Three-core mains flex, three-pin mains plug, connecting wire, spaghetti sleeving, screws, nuts, washers, solder.

Note: Capacitors and resistors with higher ratings may be used if physically compatible. Do not use higher rated SCRs, otherwise triggering will be unreliable.

A few checks can be made on the circuit if it does not work. The zener diode may be checked with a multimeter, with the power applied. The voltage reading across the zener, with the circuit untriggered, will be about 3.8V. The SCR can be checked by disconnecting the gate and connecting it to the 12.6V line via 1k resistor. This should apply voltage to the load. If the SCR is okay, the complementary SCR can be checked by connecting the sensor lead directly to the case. This should also apply voltage to the load.

Economical crystal oven





This refinement may be added to existing equipment, such as a frequency counter which uses a crystal oscillator as a reference frequency. It provides proportional rather than on-off control. All the components are readily available and are mounted on the crystal, leading to high efficiency and low power consumption.

The thermistor which I used is about 1k at room temperature. Values much different from this may require circuit changes. For correct operation the current through the thermistor (e.g. 1mA) should be much more than the base current of transistor T1 (e.g. 0.1mA). T1 and T2 should have low leakage currents. If T2 is a silicon type, increase the 150 ohm resistor to 680 ohms.

The supply voltages may be available in the existing equipment power supply. The maximum drain is only 200mA. An unregulated voltage higher than 9V would require higher value heating resistors. The power transistor T2 supplies some of the heat when the operating temperature is reached and proportional occurs. Temperature stability is dependent on the 5V supply and the efficiency of the foam insulation. Some heat unavoidably leaks away through the crystal socket.

The oven should operate a little above the maximum temperature expected inside the equipment, which should be well ventilated. Set the trimpot so the current drawn from the unregulated supply is about 30mA, with the equipment at maximum temperature. Operating temperature is reached in 5-10 minutes.

(By Mr. P. H. Mathieson, M.I.E. Aust., S.I.L. Box 115, Kathmandu, Nepal.)

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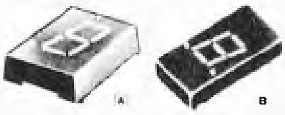

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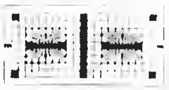

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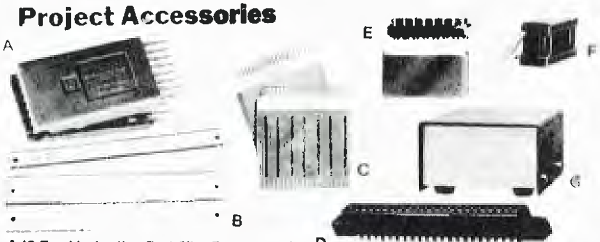

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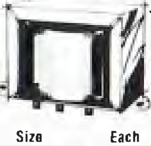

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